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K/CR-742/DEL *

Document number none — Date of document 1955-1960

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Water & Mud Data, Abee, H. H & T.C Whitson

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Date request received 5/10/96

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Date submitted to ChemRisk/Shonka and DOE 6/18/96

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From Box
CR-2
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ORGDP

ENVIRONMENTAL SAMPLING

Carbide and Carbon Chemicals Company, Operating Contractor for the U.S. Atomic Energy Commission.

Safety Records Files

Reports - Current Year - File # 147237 (4th drawer)

{Reports - Previous Years - File # 147239 (3rd drawer)

Correspondence - all years - " (3rd ")

Special Studies - all years - " (4th ")

Daily River Bulletin - legal sized file - 2nd drawer #99958

10 ml water samples

Water and Mud Data

Gross β - daily - 12

" α "

Radiochemical - biweekly

900, 00 63

7/8/60

J.A. Swartout, Deputy Director

F.R. Bruce, Director Rad. Safety & Control

ORNL

Harold H. Abee (Area Monitor)
Building 2001
(X-10)
Phone #6911 - 6263

T. C. Whitson
K-1004-D
ORGDP
Phone #8260

Wesley Cottrell - 6911

C.L. Burros - 6396 (Low Level Radiochem Lab)

Ed Struxness (Waste Disposal) 4706

F.L. Parker 6843

Y-12

7-8861

Hugh West (H-P)

McRae 7216

Fred Williams (Ind. Hyg.) 7-8698

M. Sanders 7216

Ed Roberts (Field)

UNCLASSIFIED

[redacted]

Thomas W. Tiller

[redacted]

[illegible] 6/5/96

[redacted]

This document has been approved for release to the public by:

J.J. Preston [illegible] 6/17/96

Technical Information Officer Date

ORR Site [illegible]

— DECLASSIFIED —

by authority of: J. D. McGaugh - 6/96 - LMES K-25
(CG-PGD-5) Classification Specialist
(Authorized Declassifier's name and organization)

or (Official declass. notice memo, TIC notice, etc.)

6/11/96
(Person making change) (date)

6/11/96
(Document identification verified by) (date)

THE FOLLOWING ARTICLES/PUBLICATIONS WERE REMOVED FROM THE ORIGINAL DOCUMENT DUE TO COPYRIGHT RESTRICTIONS:

1. Strontium 90 Highest in Area, The Knoxville News-Sentinel, Wednesday, July 15, 1959

2. Tennessee River Radiation Highest, The Knoxville News-Sentinel, October 4, 1959

3. Tennessee River Strontium Found, The Knoxville News-Sentinel, Wednesday, December 30, 1959

4. Radioactivity in Area Laid to Ridge Wastes, The Knoxville News-Sentinel, by Milton Britten, News-Sentinel Washington Correspondent, January 29 (year not shown)

5. The Determination of the Fluoride Content of Natural Vegetation, Vol. 6, No. 4, Journal of Air Pollution Control Association, authors: A. A. Nichol, H. M. Benedict, J. L. Byrne, and C. P. McCarty (Stanford Research Institute, Menlo Park, California) presented at the 49th Annual Meeting of the Air Pollution Control Association held at Buffalo, New York, May 20-24, 1956

6. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, Handbook #69, June 1959

7. (No specific reference shown; however, I believe it is from the same reference listed in item no. 6 except for a change in the handbook number and date) Handbook #52, March 1953

8. TVA Explains Why Lakes Are Filling up Slowly, April 20, 1960 (no newspaper name shown)

9. TVA Reservoirs Listed at About Level States, The Knoxville Journal, Wednesday, October 21, 1959

10. Annual Drawdown of Lakes Begins, The Knoxville News-Sentinel, Wednesday, October 21, 1959

11. Rains Push TVA Lakes Near Peak, The Knoxville News-Sentinel, May 8, 1958

12. TVA Lakes Hold to Good Winter Levels, January 20, 1960 (no newspaper name shown)

13. 6-Month Rainfall Below Normal, The Knoxville News-Sentinel, Wednesday, July 13, 1960

14. A-Waste in US Estimated at 65 Million Gallons, (no newspaper name shown), 1959, Monte Carlo, Monaco, November 16 (no year shown)

15. Scientists Disagree as Problem of A-Waste Grows, The Knoxville News-Sentinel, Wednesday, December 2, 1959

16. Article from Chemical Engineering Progress, on Nuclear Future, "Waste Disposal," dated February 1959, Volume 55, No. 2

UNION CARBIDE **INTERNAL CORRESPONDENCE**

NUCLEAR DIVISION

POST OFFICE BOX P, OAK RIDGE, TENNESSEE 37831

To (Name) Mr. K. W. Bahler, Mr. W. H. Hildebrand, Mr. A. P. Huber, Mr. D. M. Lang, Mr. J. A. Marshall, Mr. D. A. Overton, Mr. J. A. Parsons, Mr. J. B. Scott, Mr. R. A. Walker

Company

Location

Date September 23, 1965

Originating Dept.

Answering letter date

Copy to Mr. A. F. Becher, Mr. C. E. Center, Mr. J. Dykstra, Mr. T. E. Lane

Subject Disposal of Industrial Wastes

Pollution control of the surface water bodies in the United States has been transferred to the U. S. Public Health Service during the past few years. They are now charged with responsibility for evaluating the effects of the discharge of industrial wastes of all types, including radioelements, and the effectiveness of the controls applied by the individual state public health departments. During the past summer, they have concentrated their activities on a survey of federal agencies, among which is the Atomic Energy Commission.

Our three Carbide plants in Oak Ridge were subjected to such a survey on September 13-14, during which time the AEC, the U. S. Public Health Service, and the Tennessee Department of Public Health were made familiar with the types of waste generated at our plant, the methods of handling, and the main constituents which were being discharged to Poplar Creek and the Clinch River. These informative sessions were followed by visitations to some of the plant sites, which on this occasion did not include the K-25 area. However, it should be recognized that this was a preliminary visit and we may expect them to return for routine audits in the future. We were informed at this time that we would probably be given a clean bill of health, since there were no significant problems noted.

I wish to express my appreciation for the work that is being done in assuring that our plant is keeping within the confines of the law and good health practices, and at the same time point out a few areas in which I think our practices could be improved:

1. It would be best for a single department in the plant to be responsible for assuring that our waste streams discharging to Poplar Creek and the Clinch River, as well as the potable water supply, are routinely subjected to sampling and analysis. In this case, the Utilities Department appears to be the group best suited to do the work, and I am therefore requesting that they assume this responsibility.

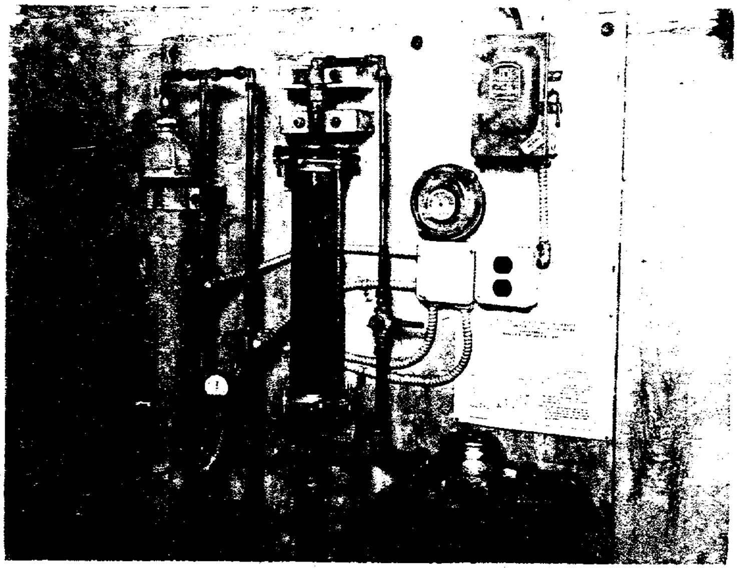
2. Each operating group must assume responsibility for assuring that significant quantities of acids or bases being discharged are properly neutralized, and where radioactive or toxic compounds may be involved, that concentrations are within the limits prescribed by the national authorities. The Utilities Department should be made aware of such releases in advance, so that the necessary sampling can be initiated. In particular, the effluent from the K-1407-B Holding Pond should be evaluated to assure that adequate neutralization is being effected. Similarly, waste discharge of a chemical nature from the administration area should be sent to the underground brick dilution basins provided for this purpose, rather than wasting them through the sanitary sewer system where they may have a deleterious effect on our treatment facilities.

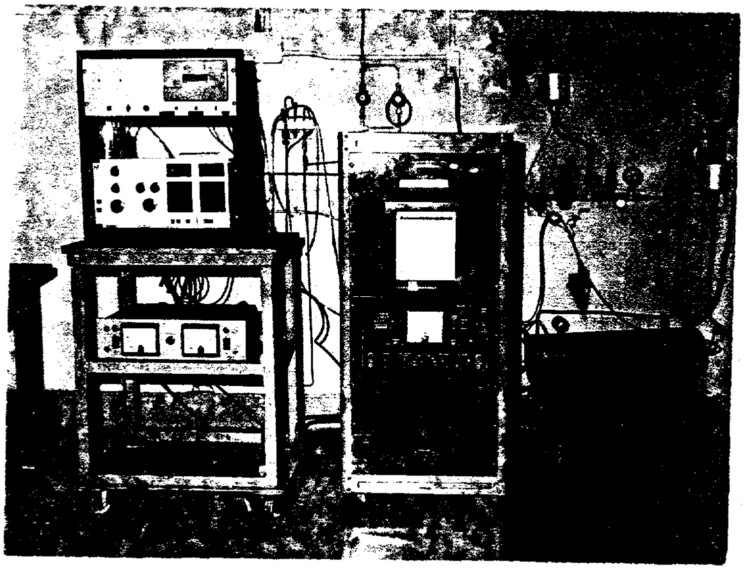
The Health and Safety group will continue to handle exotic wastes which need special attention as provided for in the Standard Practice Procedure and, in addition, will audit our plant practices as they have in the past.

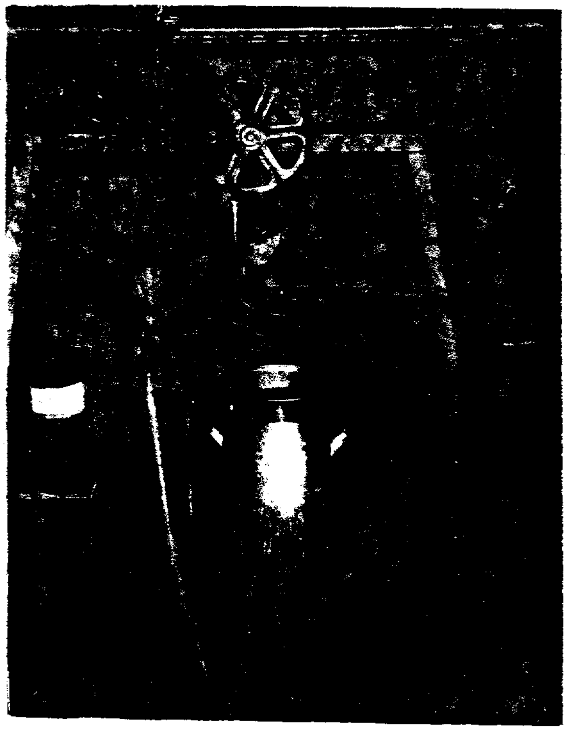
R. G. Jordan

R. G. Jordan

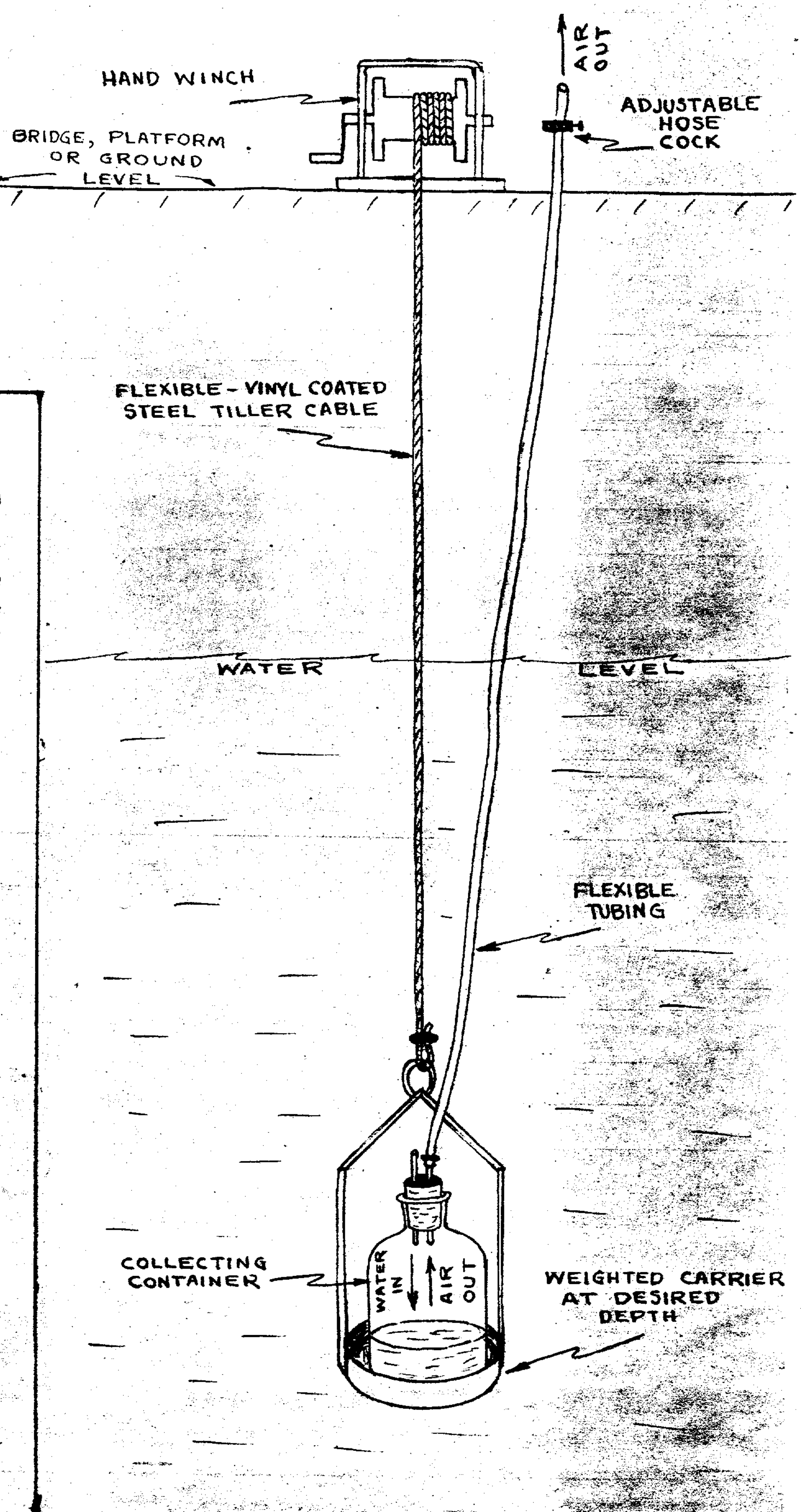
RGJ:epo







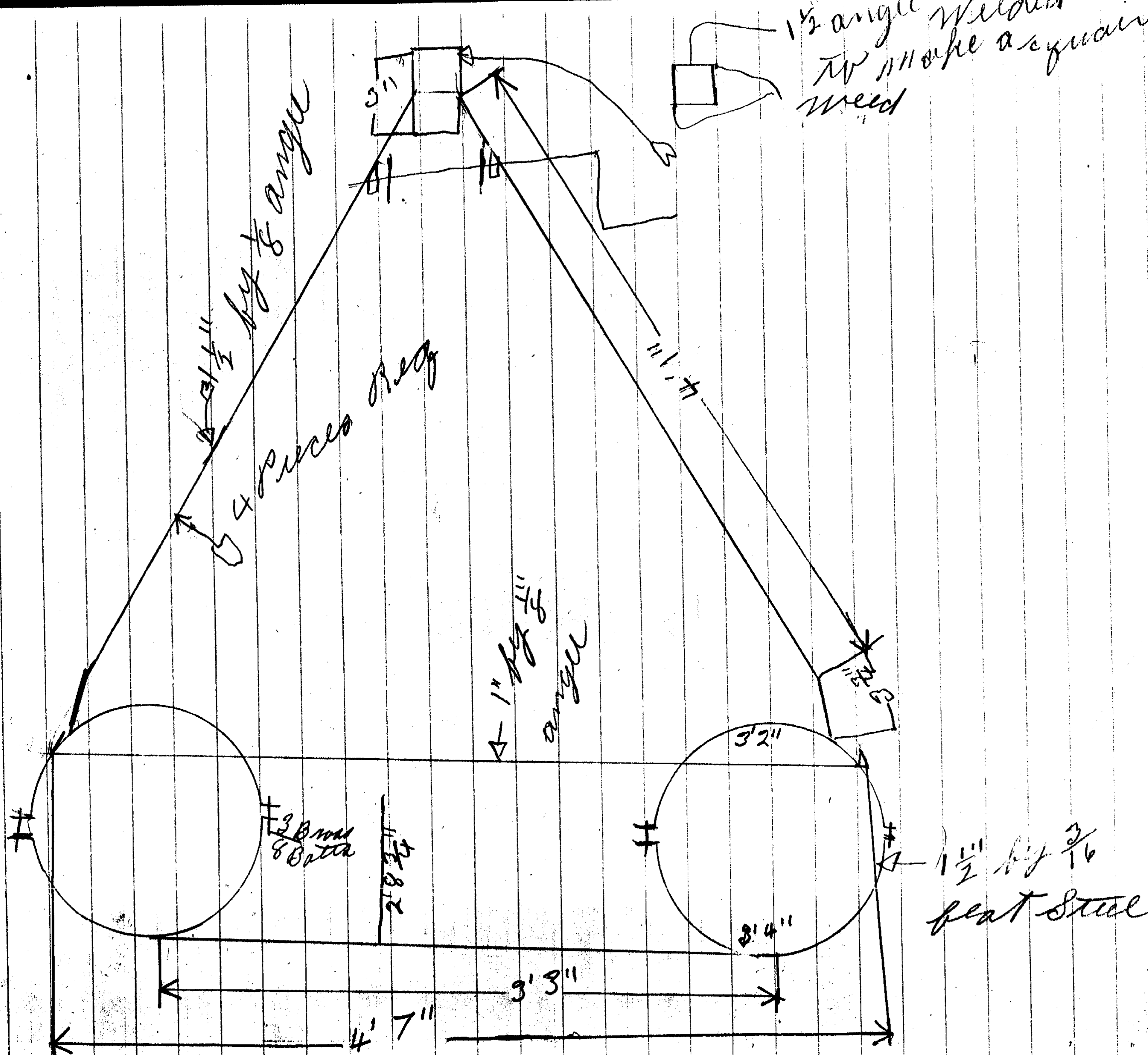
CONTINUOUS WATER SAMPLER



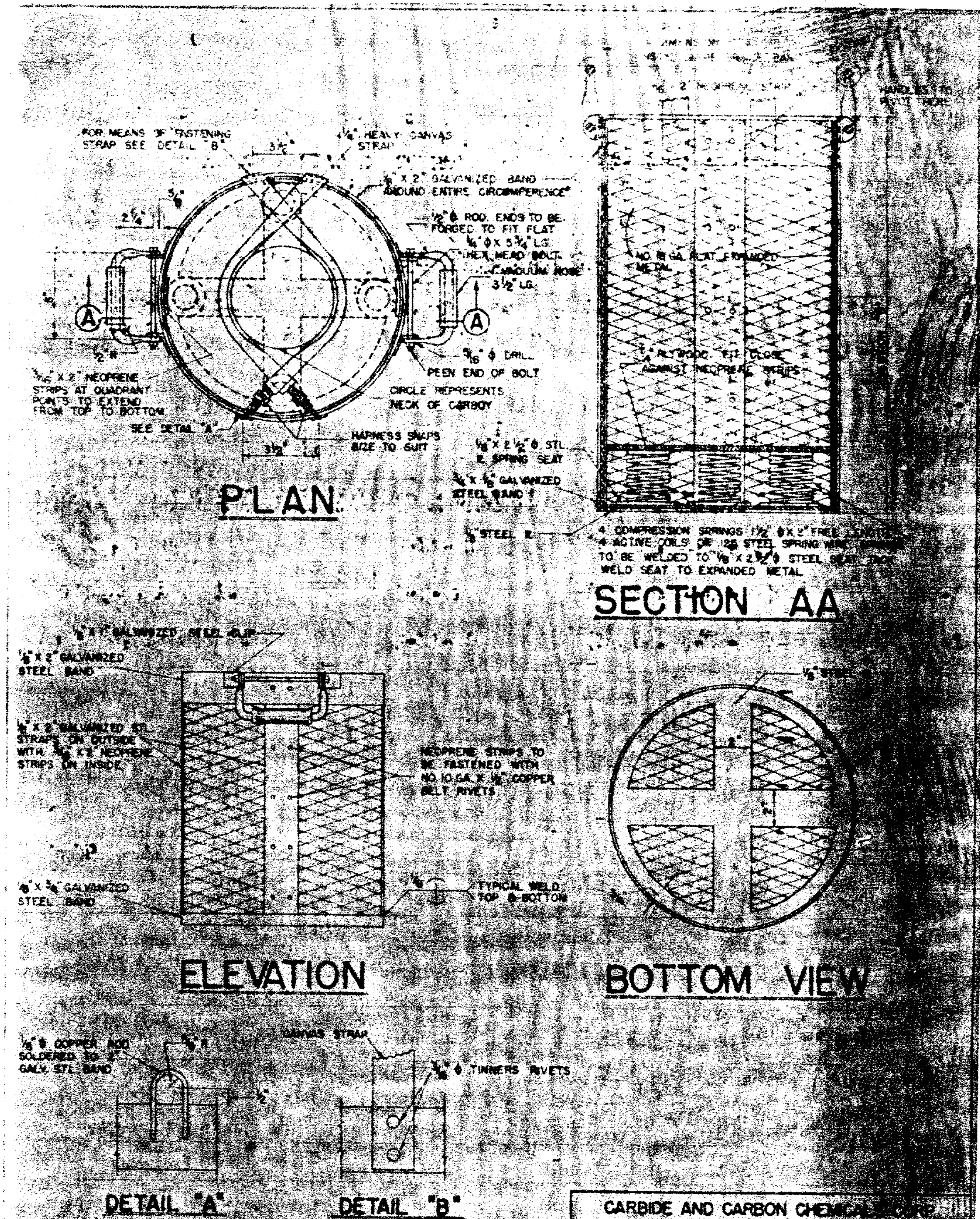
Continuous Water Sampler

This simple water sampler, submerged in the stream, collects water at a rate controlled by adjusting the release of air by means of a needle valve from the collecting bottle up through a flexible tube to the atmosphere. The sample may thus be composited over any desired period of time, such as one week. The volume collected is dependent upon the capacity of the collection container and upon the rate of air release with its resultant rate of water in-leakage.

Safety and Health Physics Dept.
Industrial Relations Division
Oak Ridge Gaseous Diffusion Plant
August 3, 1962



1½ angle welded to make a square weed
5"
1½" by ⅛ angle
4 pieces Req
4' 1"
3"
1" by ⅛ angle
3'2"
3 Brass 8 Bolts
2'8½"
1½" by 3/16 flat Steel
3'4"
3'3"
4' 7"



BOTTLE CRATE SIZES		
TYPE	DIMENSION "A"	DIMENSION "B"
1	9⅝"	1' - 3¼"
2	12⅜"	1' - 3¼"
3	8¼"	1' - 5¼"

REVISED

CARBIDE AND CARBON CHEMICALS CORP.
K-25 PLANT ENGINEERING DIVISION
OAK RIDGE,

STANDARD
BOTTLE & CARBOY CRATES

ES 91

CLASSIFICATION DETAIL

APPROVED DATE

TABLE I

Probable Maximum Permissible Concentrations of General Radioactive Contaminants Beyond the Area of Control

Kind of Exposure in	Maximum Permissible Concentration in uc/cc for β or γ emitter	α emitter
Air	10^{-9}	5×10^{-12}
Water	10^{-7}	10^{-7}

TABLE III

Location	Concentration of Radioactivity (uc/cc of water)
Average in Clinch River below ORNL in 1948	$\sim 10^{-7}$ *
Probable Max. Clinch River below ORNL in 1948	3×10^{-7} *
Curie Spring, Boulder Springs, Col.	2.6×10^{-4}
Arapahee Spring, Boulder Springs, Col.	0.6×10^{-4}
Clark's Magnetic Spr., Pueble Cy., Col.	9.7×10^{-7}
Old Cave Spr., Glenwood Hot Spr., Col.	2.2×10^{-6}
Hartsel Hot Spr., Col.	4×10^{-5}
Mansion Spr., Col.	1.3×10^{-6}
Hortense Spr., Col.	6.4×10^{-5}
West Mound Spr., Ponshe, Col.	7.4×10^{-5}
Flute, French Lick, Ind.	4.9×10^{-7}
Old Orchard Min. Spr., Mo.	4.3×10^{-7}
Nauheim, Glen Spr., N.Y.	2.6×10^{-5}
Novarik and McKeehan, O.	2.2×10^{-6}
Tiega Min. Wells, Fitch, Tex.	2×10^{-6}
Magnesian Spr., Va. Hot Spr., Va.	9.3×10^{-5}

* These two values are β activity due to ORNL operations. The average α activity in the Clinch River due to ORNL operations is negligible. The other values in the column are for radon.

See letter from Karl Z. Morgan, January 24, 1949, to Members of the Sub-Committee on Permissible Internal Exposure.

ORGDP ENVIRONMENTAL MONITORING
Water and Mud

In discussing the ORGDP water and mud sampling program, we will include both our legal and moral responsibilities in controlling exposure to the general population downstream from the UCNC plants in Oak Ridge. The ORGDP routine monitoring program, emergency controls, and comparison of the actual radiation levels in the ORGDP environs with maximum permissible concentrations recommended by the NCRP are also discussed.

In 1945 Tennessee passed a stream pollution act to regulate and control the pollution of the surface waters and streams of the state; this act is administered by a Control Board, whose membership includes representatives from industry, public health, municipalities, and conservation. The state law indicates that no substances should be discharged to the waters which may produce toxic conditions that materially affect man, animals, and aquatic life, or impair the potability of a treated water supply. With its limited personnel and equipment, the state commission relies upon the ORO of the USAEC and the TVA for information as to their waste disposal problems and stream levels affected by their operations.

Under the AEC Regulation, Chapter 0524, standards established by the NCRP and recommended by the NBS are to be considered as minimum requirements for commission contractors.

ORGDP SPP-310, entitled "Disposal of Hazardous Materials" outlines the plant policy relative to disposal of hazardous materials. This provides that such disposal be in accord with applicable laws and regulations to preclude endangering persons, property, animals, or vegetation. The limitation of exposure for those under 18, as well as for adults living in areas proximate to the plant shall be only one-tenth the amount permitted for the plant population, and that all other areas shall not receive significantly more than background levels of radiation.is an indication of the levels sought.

Our objectives are to protect our plant population as well as the general population downstream. Protecting ourselves involves evaluating and controlling the fission product contamination in the ORGDP sanitary water in order to assure that personnel exposures due to this source are less than 10% of the P.A.L. for total body exposures. Protecting the general population involves detection of contaminants not only in our plant effluents but also the combined effect of all of the UCNC plants at Oak Ridge and institution of controls where needed to prevent stream pollution deleterious to marine, plant, or animal life. We must also have plans for handling emergency conditions which may result from abnormally high concentrations of radioactive contaminants in the ORGDP sanitary water supply.

(Map of Tennessee River)

The flow of water in the reach of the river of interest to us is controlled by the discharge from Norris Dam and the elevation of the water impounded by the Watts Bar Dam.

(Map of ORO Area)

It may be seen that disposal from Y-12 is dispersed into the Clinch River by way of Bear Creek, East Fork of Poplar Creek, and Poplar Creek itself. ORNL waste disposal is via the low-level waste pits to White Oak Lake and thence to the Melton Branch of White Oak Creek and the Clinch River.

(Map of ORGDP)

The ORGDP sanitary water supply is taken from the Clinch River approximately one mile upstream from the Powerhouse and about six miles downstream from the ORNL plant site. Mixed fission product waste materials are routinely released from the ORNL to the Clinch River via White Oak Creek. Formerly the creek had been dammed and formed what was called the White Oak Lake which acted as a holding basin for the ORNL waste materials; however, due to the lack of adequate weiring and flood gates at the dam outfall, little if any control of the discharge could be made following heavy rainfall or during flooding. The lake was drained in 1956 and, at the present time, the waste materials enter the creek and pass in a relatively steady controlled flow into the river. As a result of this controlled release, the activity in the river has been maintained at a more constant level with a minimal number of high peaks of activity such as were noted during the period of uncontrolled flows from the White Oak Lake. Dilution of radioactive contaminants released from White Oak Lake depends on the Clinch River flow. Actual current flow and predicted future releases of water from Norris Dam are made available by the TVA with about a two-day lag. ORNL has a policy of releasing only that amount of activity which will give below-tolerance concentrations following dispersion and dilution in the Clinch River based on the predicted TVA flow rate and assuming homogeneous mixing in the river between ORNL and ORGDP. Thus, while concentrations of radioisotopes should normally be less than the permissible levels at the ORGDP water treatment plant intake, they may be exceeded on occasion. The isotopes of immediate concern in this connection are Sr^{89} and Sr^{90}. Sr^{90} is particularly hazardous to man because it is chemically similar to calcium, and the human system readily absorbs it along with the calcium in vegetables and deposits it along the surfaces of the bones in the human skeleton where it can irradiate the blood-producing marrow inside the bone. (long half-life – 25 years)(slow elimination)

It is well to remind ourselves that the MPL's for these materials are based on the possible genetic effect on huge populations if encountered over a lifetime; no clinically detectable injury is experienced at these levels;

(destroys activity of bone marrow) (formation of tumors), they are used as control points to integrate exposure over longer periods, at least 13 weeks, and the average level found in our water supply is only a fraction of the MPL. The difficulties in exactly calculating the number of curies to release to assure safe limits for all users may be noted by the wide variations in the Clinch River rate of flow during a 24-hour period, its stratified stream flow, the effects of numerous sharp bends in the river course, and differences in depths of stream bed.

(Photograph of K-1513 Sampler)

The raw water supply is sampled at the K-1513 Pump House where the water is taken from the Clinch River. This sampler is an electrically operated water-wheel type of drive to which a sample bucket is attached. You may note the resemblance to the children's sand-box toy, "Sandy Andy." About 10 ml. of water is discharged every two minutes to a five-gallon carboy which is composited to reflect a seven-day proportionate sample.

Since the plant allowable limit for beta activity in the plant drinking water is based on that which is due to Sr^{90}, the most hazardous of the mixed fission product waste materials, and the concentration of this isotope has varied from 25% to 100% of the identifiable fission product wastes, it is necessary to determine that portion of the total beta activity measured which is due to the Sr^{90} isotope. The levels of activity due to this isotope which are of concern are so low as to not be measurable with usual survey instruments, nor even normal laboratory procedures. Since this is so, an ion exchange method has been developed to concentrate the Sr radioactivity in the plant water supply. This is installed at the K-1515 Water Treatment Plant, and a 24-hour sample is collected each morning at 7:00 a.m.; the analysis and counting of the sample is completed by 4:00 p.m. of the same day.

A second continuous collecting device is located in the finished sanitary water system at the K-1513 Post Chlorinator position. This device utilizes a needle-valve which permits adjustment to secure a proportionate sample; the water drips continuously into a carboy and, here too, the sample is composited weekly. Other check points for determining the total beta activity in the treated sanitary water supply include spot sampling of the plant drinking fountains and the cafeteria cooking water supply.

All of the plant waste materials are released into Poplar Creek which bisects the ORGDP area and then empties into the Clinch River about one-half mile downstream from the last major drain effluent. Poplar Creek also carries the Y-12 Plant waste materials released into the East Fork Branch which subsequently empties into Poplar Creek about one-half mile above ORGDP.

Radioactive materials in streams are absorbed by biological organisms by clay particles occurring as turbidity in streams, or precipitated out by either physical or chemical means, resulting in the accumulation of radioactive substances in the sediment. Naturally occurring radioactive isotopes of uranium, thorium, and potassium, account for from 25% to 40% of the radioisotopes in the Clinch and Tennessee Rivers; the remainder of the radioactivity is from fission products of which the most prominent are ruthenium, cesium, cobalt, and cerium.

(Photographs of Mid-stream Sampler)

Continuous water sampling devices are placed in three mid-stream locations in order to detect the uranium concentration of Poplar Creek and the downstream dispersal and dilution of the radioactive contaminants in the Clinch River. These sampling units consist of a small raft from which a weighted carboy is suspended, being adjustable to varying depths. A capillary adjustment, allowing a constant displacement of air by water into the carboy, is regulated to provide a proportionate weekly sample which is then composted for analysis. These continuous samples are located as follows:

a. East Fork Branch near its junction with Poplar Creek, which permits the amount of waste material reaching Poplar Creek from the Y-12 Plant to be calculated.

b. Poplar Creek near its junction with the Clinch River; this measures the total uranium concentrations in the stream and, since the East Fork concentration is known, the net ORGDP contribution may be calculated.

c. Clinch River one mile downstream from the Poplar Creek junction measures the contribution of all of the waste materials contributed by the three Oak Ridge Plants.

In addition to the composite water samples, spot samples of stream bottom mud and certain building drain systems are taken quarterly to evaluate any possible build-up of contaminated silt, as well as to check on operational changes which may produce abnormal releases of materials. All water samples taken are analyzed for total uranium content and the associated alpha and beta activity; in addition, the fluoride content and pH values are also measured. Other routine checks include those made of the acid drain lines, wastes from the laboratory areas, and the sewage disposal plant sludge which is sampled before it is dumped.

Special studies are made periodically of the accumulation of radioactivity by the absorption of uranium from the slightly contaminated plant effluents in clay, silt, vegetation, and fish.

Emergency Controls

In the event of an accidental spill or release of waste material at ORNL which would result in an abnormally high level of beta activity in the White Oak Creek, certain emergency procedures have been suggested to minimize the

the possibility of contaminating the ORGDP sanitary water supply.

In the event of a "known" release from ORNL, which may be controlled behind White Oak Dam, the material would be held up until it can be released slowly into the Clinch River and thus adequately diluted. The potential danger due to overfilling of the lake with a subsequent uncontrolled release or unusually heavy rainfall would exist; however, this is considered remote.

If the high activity reaches the Clinch River, ORNL authorities will alert the ORGDP Shift Superintendents, who, in turn, will notify the Utilities Department and other staff groups as indicated. Sampling frequency would be increased at the raw water intake, and sanitary water consumption reduced to extend the normal nine-hour reserve supply. Disaster control actions, if indicated, would include shut off of raw water intake, further limitations of sanitary water consumption, provision of potable water from an uncontaminated source, and continued sampling of raw water until levels return below the action point.

In the event of an "unknown" release from upstream which is first detected at the ORGDP K-1515 Sanitary Water plant, when noted for the second consecutive day ORNL will be requested to check their discharge of waste and initiate control measures. If ORNL does not find a continuing release and identifies the "slug" which was sampled, then the high activity may be expected for no longer than approximately 48 hours. If ORNL discovers a continuing release of high activity radioactive contamination, and controls can be quickly established, then the situation can be covered as above. If controls cannot be immediately established, the period over which the release will continue uncontrolled is evaluated and the new exposure rate is calculated; if it is less than the control point, no further actions need be considered. If the calculated dose rate is greater than the control level, then disaster controls will be initiated.

(Chart, MPL and Current Values)

MPL's are established by NCRP and recommended by the NBS. Since all of these limits are given for continuous exposure, the corresponding plant limits for a 40-hour week can be three times the continuous exposure value. However, for administrative purposes to avoid the need for integrating employee dose from all exposure sources, our plant limits specified for the potable water supply are set at < 10% of these permissible levels. The problems of health hazards involved in the discharge of uranium materials in the ORGDP waste appear of minor consequence in view of the stringent limits desired for economical reasons.

These average values indicate that the activity levels in the water and bottom sediments in the Clinch and Tennessee Rivers resulting from waste release by the three Oak Ridge plants are well below those recommended by the NCRP and thus do not represent any hazard to the plant or the population in the areas adjacent to the plant. However, continuing vigilance must be maintained to insure that build-up or reconcentration of the radioactive materials do not create a problem at some future date.

NBS:la

8/14/59

If aqueous waste is run into a pit, it will percolate downward until it joins the ground water. The rate of percolation will depend on the compositon of the waste, composition of soil, geological structure of areas such as faults, gravel, and rock layers. The radioactive contaminants will travel less rapidly than the liquid, for they will be absorbed to varying degrees by the clay fraction of the soil.

nbs

MONITORING PROGRAM FOR RADIOACTIVE CONTAMINANTS IN THE ORGDP

SANITARY WATER SYSTEM AND THE PLANT DRAINAGE SYSTEM

Purpose: It is the purpose of this report to define the objectives of the ORGDP for contamination control of streams and the sanitary water supply and to review the methods and procedures currently used or proposed for use pursuant to these objectives.

Objectives:

1. To evaluate and control the fission product contamination in the ORGDP sanitary water in order to assure that personnel exposures due to this source are less than 10% of the plant acceptable limits for total body exposure.
2. To detect contaminants in plant effluents and to institute controls where needed to prevent stream pollution deleterious to marine, plant, or animal life.
3. To formulate procedures for the handling of emergency conditions which may result from ~~dangerously~~ abnormally high concentrations of radioactive contaminants in the ORGDP sanitary water supply.

ORGDP Sanitary Water Supply

The plant sanitary water supply is taken from the Clinch River approximately one mile upstream from the ORGDP Powerhouse and about six miles downstream from the ORNL plant site. Mixed fission product waste materials are routinely released from the ORNL to the Clinch River via White Oak Creek. Formerly, the creek had been dammed and formed what was called the White Oak Lake which acted as a holding basin for the ORNL waste materials; however, due to the lack of adequate wiering and flood gates at the dam outfall, little if any control of the discharge could be made following heavy rainfall or during flooding. The lake was drained in 1956 and, at the present time, the waste materials enter the creek and pass in a relatively steady flow into the river. The chemical elements involved as well as the total curies of activity released from the ORNL storage tanks to the White Oak Creek are known, and as a result of controlled release, the activity in the river has been maintained at a more constant level with a minimal number of high peaks of activity such as were noted during the period of uncontrolled flows from the White Oak Lake.

Sampling and Monitoring of the Sanitary Water Supply

The raw water supply is sampled at the K-1513 Pump House where the water is taken from the Clinch River. A continuous collecting device discharges about 10 ml of water every two minutes to a five-gallon carboy which is composited to reflect a seven day sample. ~~In addition,~~ Since the plant allowable limit for beta activity in the plant drinking water is based on that which is due to Sr^{90}, the most hazardous of the mixed fission product waste materials and the concentration of this isotope has varied from 25-100% of the identifiable fission product wastes, it is necessary to determine that portion of the total beta activity which is due to the Sr^{90} isotope. Therefore, an ion exchange method of determining Sr^{90} radioactivity in the plant water supply is employed at the K-1515 Treatment Plant, with a 24-hour sample collected each morning at 7:00 A.M. and the analysis completed by 4:00 P.M. of the same day.

A second continuous collecting device is located in the sanitary water system at the K-1515 Post Chlorinator position. The device utilizes a needle valve which allows the water to drip continuously into a carboy and here too the sample is composited weekly.

Other check points for determining the total beta activity in the treated sanitary water supply include spot sampling of the plant drinking fountains and the cafeteria cooking water supply. ~~Locations and frequency of sampling are indicated in Table 1.~~

~~Analyses for uranium, alpha activity, beta activity, pH, and fluorides are obtained, as noted in Table 2.~~

Emergency Procedures

In the event of an accidental spill or release of waste material at ORNL which would result in a ~~"dangerous"~~ abnormally high level of beta activity in the White Oak Creek, certain emergency procedures have been established to minimize the possibility of contaminating the ORGDP sanitary water supply and are as follows:

I. Known Release from ORNL

A. Controlled behind White Oak Dam; material is held up until it can be released slowly into the Clinch River and thus adequately diluted. The potential danger due to overfilling of the lake with a subsequent uncontrolled release would exist; however, this is considered remote.

B. High Activity reaches Clinch River

1. ORNL authorities alert ORGDP Shift Superintendents Office.
2. The Utilities Department is notified by ORGDP Shift Superintendents and the sampling frequency is increased as indicated (Estimated time to reach ORGDP is 48 hours).
3. ORGDP Shift Superintendent notifies the Health Physics Department, and other groups as indicated.
4. Reduce sanitary water consumption. A storage tank contains nine hours supply under normal usage; this period may be extended by curtailing the use for processes not immediately

essential for plant operations.

5. If the five-day average activity in the water exceeds a level of (6900) d/m/100 ml, representing MPC for a 13-week period based on a 24-hour day industrial exposure, disaster control action should be effected as follows:

   a. Shut off raw water intake.

   b. Limit sanitary water consumption.

   c. Request TVA officials to increase flow of Clinch River for additional dilution.

   d. Bring in potable water from uncontaminated source.

   e. Continue sampling of raw water until levels return below the 13-week effective average (6900 d/m/100 ml).

II. Unknown Release from ORNL

A. ORGDP K-1515 Sanitary Water Plant first detects significant increase above normal levels of total beta activity.

B. Check previous records to determine effective average for 13-week period.

C. Check following day and if effective 13-week average (6900 d/m/100 ml) is exceeded, the following actions should be taken:

   1. Notify ORNL to check and initiate control measures.

   2. If ORNL discovers no continuing release, then high activity may be expected for two or three more days. If the estimated five-day average is less than the 13-week effective average, no further actions need be considered.

   3. If ORNL discovers a continuing release of high activity radioactive contaminants.

      a. Assuming controls can be quickly established, then C-2 above applies.

b. Assuming controls cannot be immediately established, determine the period over which the release will continue uncontrolled. Add three days as in C-2 above; calculate the new exposure rate and if it is less than the 13-week effective average, no further actions need be considered. If greater than the 13-week effective average, initiate disaster controls as ~~described in I.B.5.~~

Control of Uranium Concentrations in the ORGDP Drainage System

All of the plant waste materials ~~after treatment~~ are released into Poplar Creek which bisects the ORGDP area and then empties into the Clinch River about one-half mile downstream from the last major drain effluent. Poplar Creek also carries the Y-12 Plant waste materials into the East Fork Branch which subsequently empties into Poplar Creek about one-half mile above the ORGDP.

Water and Mud Sampling Procedures of Poplar Creek and Clinch River

Continuous water sampling devices are placed in three mid-stream locations in order to detect the uranium concentration of Poplar Creek and the downstream dispersal and dilution of the radioactive contaminants in the Clinch River. (B) One each continuous sampling device yielding a weekly composite is located in the East Fork Branch near its junction with Poplar Creek so that the amount of waste material reaching Poplar Creek from the Y-12 Plant may be calculated. A second sampling device, located in Poplar Creek near the stream's junction with the Clinch River, measures the total stream uranium concentration ~~and,~~ Since the East Fork concentration is known, the net ORGDP contribution may be calculated. The third continuous sampling device is located in the Clinch River one mile downstream from the Poplar Creek junction to check the downstream dilution and dispersal of the waste materials contributed by all three plants. ~~The locations of the sampling points are shown in Figure 1.~~

In addition to the composite water samples, spot samples of stream bottom mud and certain building drain systems are taken quarterly to evaluate any possible build-up of contaminated silt, as well as operational changes which may produce abnormal releases of materials. (~~See Table 1.~~) All water samples taken are analyzed for total uranium content and the associated alpha and beta activity; in addition, the fluoride content and pH values are also measured. (~~See Table 2.~~) Other routine checks include those made of the acid drain lines, wastes from the laboratory areas, and the sewage disposal plant sludge which is sampled each time before it is dumped.

Special Studies

Special studies are made periodically of the accumulation of radioactivity by the absorption of uranium from the slightly contaminated plant effluents in clay and silt, vegetation, & fish, ~~and residual substances in local streams.~~

GSH:NBS:erc

4-29-59

A STUDY OF THE URANIUM CONCENTRATION AND ALPHA ACTIVITY IN THE ENVIRONMENTAL AIR, SOIL, AND VEGETATION AT ONE-MILE, TWO-MILE, AND FIVE-MILE DISTANCES FROM THE CENTER OF THE OAK RIDGE GASEOUS DIFFUSION PLANT DURING 1960 AND 1961

INTRODUCTION

During the early part of 1960 a study was initiated to evaluate the effect of the waste uranium material routinely released from the Oak Ridge Gaseous Diffusion Plant vent stacks on the outside environmental air as measured by the levels of alpha activity. In addition, soil and vegetation samples were examined to determine the extent of build-up of uranium in the soil and the uptake of uranium by vegetation.

Sampling points were established on major compass points encircling the plant at 1-mile (plant boundary), 2-mile, and 5-mile distances from the center of the plant. The studies covered a period from April 1960 through June 1961.

Methods of Sampling

Air samples were taken at the 1-mile or plant boundary continuously over a period of at least one week during each quarter of the year. Samples taken at the 2-mile and 5-mile locations consisted of 10-20 minute spot samples obtained by filtering the air through No. 40 Whatman filter paper, utilizing a Hi-Vol portable sampling device.

Soil samples consisted of surface soil removed to a depth of 4 inches.

Vegetation samples consisted of various grasses containing both leaf and root systems. In addition, where available, separate samples of pine needles were collected.

Background

Samples of air, soil, and vegetation were collected at a distance of 12 miles from the plant in a southwesterly direction considered to be out of the normal path of prevailing winds and thus levels would not be significantly influenced by plant conditions. The levels of alpha activity and uranium concentrations at this location are taken as background for the plant environment.

Prevailing Winds

According to a meteorological survey made by the AEC, the prevailing wind direction is in a northeasterly direction for the major part of the year. Figure ____ shows the wind directions and velocities for the area. Periods of envisions occur frequently in the winter months, especially during the early morning hours and within the plant area wind direction varies greatly as a result of building obstructions.

Alpha Activity in Air

The average alpha activity in the environmental air at 1-mile, 2-mile, and 5-mile distances and at various directions from the plant are shown in figures 1, 2, and 3, respectively.

One Mile from Center of Plant (Plant Boundary)

The average alpha activity during 1960 did not vary significantly as related to the prevailing wind direction. It may be assumed that the variation of surface wind directions about the plant area and the closer proximity of some sampling devices to vent stacks are factors influencing the fallout pattern within the immediate environs of the plant during the time of sampling.

Two Miles and Five Miles from Center of Plant

The average air activity at major compass points during 1960 at the 2- and 5-mile distances indicate a definite pattern of fallout as influenced by the prevailing wind direction being consistently higher in the northern direction. During 1961 levels in all directions were not significantly different from background. The topography of the area within these distances consists of low mountain ridges approximately 1,000 feet high with narrow valleys running almost due East to West. Air samples were taken at the eastern 2-mile and 5-mile sampling points on top of the ridge as well as in the adjacent valley. No significant change in the average air levels were noted for the different elevations.

Air sampling at the 2-mile locations was discontinued during 1961 since results revealed levels at both 2- and 5-mile distances were near background and did not differ enough to warrant sampling at both points.

Alpha Activity and Uranium Concentration in Soil and Vegetation

While the average air activity did not indicate the influence of prevailing wind direction or fallout at the 1-mile distance, it is distinctly shown in the uranium concentration and corresponding alpha activity of the soil and vegetation, being higher in the North and East directions. In general, levels were also higher at the sampling points in these directions at the 2-mile and 5-mile locations.

It may be noted that in both the soil and vegetation samples the alpha activity curve follows that of the uranium concentration very closely as would be expected for routine release of material of normal assay. It would appear that only one, either the uranium concentration or alpha activity, need be ascertained as an indicator of uranium build-up in soil and vegetation unless, of course, known releases of enriched materials have occurred.

A comparison of the uranium concentration in the grasses with that of the pine needles revealed no significant differences in the uptake of uranium. Since the grass samples are more easily available at sampling locations, the use of pine needles as an indicator of plant uptake of deposited uranium was discontinued during 1961.

Results of samples taken at 1-mile, 2-mile, and 5-mile locations indicated levels of uranium concentrations in the soil to be quite low and in most cases near background. No significant uptake of uranium by plants in the environmental area of the plant was found.

GSH:la

10/12/61

MEMORANDUM

To: Files (Environmental Sampling, Water & Mud)

Subject: Continuous Beta Water Monitor, Tracerlab

On Friday, September 11, 1959, a vendor's instrument display in the Alexander Hotel in Oak Ridge was visited by W. C. Hartman and C. C. Fowlkes of Utilities, J. H. Goodwin and W. W. Smith of Instrument Maintenance, H. F. Henry and N. B. Schultz of Safety, Fire, and Radiation Control, for the purpose of discussing with Mr. John Eills of Tracerlab, Richmond, California, their continuous beta water monitor.

While such an instrument was not available for visual inspection, photographs of the components were observed and partial information secured as to design features, limits of operation, etc.

The basic instrumentation apparently has many years of field service behind it; the tube being developed about 5 years ago. This tube is a straight anode under tension, with the gas being a common geiger gas consisting of 99% helium and 1% isobutane, the latter quenching the discharges and ultimately being consumed. Should a microscopic hole develop, back diffusing of oxygen plays havoc with tube sensitivity, and the geiger gas could leak out, either requiring tube replacement. The tube wall is of 30mg/cm^2 stainless steel, is reportedly not particularly fragile and will "flex". Water to be sampled with pressure maintained about 10 psig enters through a ½" inlet tangentially, filling the 3/4" space between the container and the tube, approximating ½ pint. The tube is provided with a polyethylene sleeve, 7mg/cm^2, costing about 15¢ each, to be changed when residual contamination builds up; six such covers are supplied with each tube. The tube, costing about $165, has a shelf-life of one year or more and a useful life of 10^8 total counts.

In the water monitor, the tube is surrounded by a 2" lead container, 8"x22", weighing about 500#. Sensitivity of the tube is 2×10^{-6}uc/ml in an energy range believed to be between 300kev and 3000kev, or approximately 520 d/m/100ml. If it is desired to add a 4 minute time constant, then the instrument could read 80-100 d/m/100ml above the 260 c/m background noted when the sample is of non-radioactive water. Rate-meter scales available include ranges from zero to 100, 250, 1000, 2500, 10,000, or 25,000 d/m/sample.

Mr. Eills stated that the tube is essentially transparent for gamma radiation, seeing less than 1%. This agrees with information previously received independently from A. R. Flynn of ORGDP and W. L. Cottrell of ORNL who indicated they would expect less than 1% gamma to be seen by this type instrument.

Variations in tube geometry might be expected if the sample volume is not kept full of water. Relative to aging of the tube, Mr. Eills commented that normally the plateau is 200 volts long, and while the plateau may shrink some with age, it is still usable; he recommended a plateau check be run about once each month. In a sense, the strip-chart would serve as an "automatic" plateau plotter during normal operation. The possibility of a tube failing suddenly was proposed; such an occurrance should be fairly obvious, since the counting rate would drop to zero or a continuous alarm occur if the tube "jams".

A proposed design suitable for the ORGDP installation (estimated cost $3000) will be drawn up by Tracerlab engineers and more complete information on the operating characteristics will be forwarded to W. C. Hartman, with receipt anticipated by October 1, 1959.

N. B. Schultz

NBS:nbs
9/14/59

~~[illegible]~~

U

31,621.3 # UO_2F_2 (natural)

Min. Flow: PC — (20 ft³/sec) (≈ 5 × 10⁷ liters/day) [50 × 10⁶]
CR — (2850 ft³/sec) (7 × 10⁹ l/day) [7,000 × 10⁶]
USG min. flow

U^N (Spec. Act.) { 2.5 × 10⁴ dis/sec/gram
1.5 × 10⁶ dis/min/gram

NBS (#69) (6-5-59)

U^N MPC_w { 2 × 10⁻⁴ μc/cc (168 hr-occup.)
2 × 10⁻⁵ μc/cc (1/10 × 168 hr)
FRC { 7 × 10⁻⁶ μc/cc (1/30 × 168 hr)

1 curie (U) ≈ 7.5 × 10¹⁰ dis/sec
(NBS #69)

42

8609
3

~~R actually see?~~
~~Stokes conversation?~~

8409

X

Lauderbach 6/27/62
communists fall down

no one saw — hearsay
told conyers —
later told superv.

$$
\begin{array}{r}
4.79 \\
3\,\overline{)\,14.378} \\
\underline{12} \\
23 \\
\underline{21} \\
27 \\
\underline{27} \\
8
\end{array}
$$

12-B
Gold
Red
871/2

didn't know had to carry
to check (ℰ disp.)
left word w/ Noel Howard
check or charge — let me vote
~~form~~ if carry — 809 Howard.
have to carry

Noel called disp.
girls 8-9282 / not much @ clerks

Tues

Kg × 2.2 = #

$2.2 \overline{)31621.3}$ = 14,373.7 (long division worked in margin)

U.

$\frac{31,621.3\ \#}{2.2\ \#/kg} = 14,378\ kg.$

$\frac{7.5 \times 10^{10}\ dis/sec/curie}{2.5 \times 10^{4}\ dis/sec/gram} = 3 \times 10^{6}\ g/c$

$3 \times 10^{6}\ g/c = 3,000\ kg/c$

$\frac{14,378\ kg}{3,000\ kg/c} = 4.79\ c$ of uranium

——— X ——— X ———

$2 \times 10^{-5}\ \mu c/cc = 2 \times 10^{-11}\ c/cc$

$= 2 \times 10^{-8}\ c/liter$

PC/day $(5 \times 10^{7}\ l)(2 \times 10^{-8}\ c) = 10 \times 10^{-1}$

$= 1\ c/day$ 3 c/day FRC

CR $= \frac{7 \times 10^{9}}{5 \times 10^{7}} = 1.4 \times 10^{2} = 140\ c/day$

47 c/day FRC

% dilution

$\underline{\underline{F_2}}$

$\underline{UO_2F_2}$

$U - 238 \times 1 = 238$

$O_2 - 16 \times 2 = 32$

$F_2 = 19 \times 2 = \underline{38}$

308

$\frac{38}{308} = 12.3\ \%\ F_2$

$12.3\%\ F_2 \times 14,378\ kg = 1768.49$

$\frac{1768.5\ kg\ F_2}{5 \times 10^7\ kg\ water} = \frac{1769}{50} = 35.38\ ppm$

PC

$\underline{C.R_1}$

$\frac{35}{140} = 0.25\ ppm$

$\frac{72}{238}$ $\frac{8}{16}$ $\frac{9}{18}$
$U\,O_2\,F_2$

$\cancel{F_2}$

USPHS — { 1.5 ppm — industrial waste
1.0 ppm — human consumption

31,621.3 # UO_2F_2

MIN. FLOW { PC — 5×10^7 l/d = 5×10^{10} gms = 5×10^7 kg/day
CR — 7×10^9 l/d = 7×10^{12} gms = 7×10^9 kg/day

$\frac{31,621.3\#}{2.2\ \#/kg} = 14,378$ kg UO_2F_2

$\frac{238}{18}$ 272 $\quad \frac{18}{272} = 6.7\%\ F_2 \times 14,378\text{kg} = 962$ kg

$\frac{962 \text{ kg } F_2}{5 \times 10^7 \text{ kg water}} = \frac{962 \text{ kg } F_2}{50 \times 10^6 \text{ kg water}} = 20$ ppm P.C.

$\frac{20}{140x}$ = 0.14 ppm — CR (w/o extra dilution)

.123
308) 38.0
30 8
720
616
1040

10 ppb $\cong$ 1×10^{-8} g of U / g water = .01 µg U / g H_2O

Spec. Activity U Normal = 2.5×10^4 d/s/g

$$\frac{(2.5 \times 10^4)(1 \times 10^{-8})}{3.7 \times 10^{10}} = 0.7 \times 10^{-14} \text{ curie / gram of water}$$

$= 0.7 \times 10^{-8}$ µc / g of water

$= 7 \times 10^{-9}$ µc / ml water (140 ppm $\cong 1 \times 10^{-4}$; 700 ppm $\cong 5 \times 10^{-4}$)

MPC for Unknown alpha emitters in water: 10^{-7} µc/ml (22.5 d/m/100 ml)

Spec. Activity of Normal Uranium = 2.5×10^4 d/s/g

$= 1.5 \times 10^6$ d/m/g = 1.5 d/m/µg

= 0.5 c/m/µg

MIT .04 c/m/ml = 1.8×10^{-8} µc/ml
1 c/m/ml = 45×10^{-8} µc/ml

nbe 10 ppb $\cong 7 \times 10^{-9}$ µc/ml ; $\times 3.7 \times 10^4$ d/s/µc = $25.9 \times 10^{-}$ d/s
10 ppb = 1.6×10^{-2} d/m/ml
1000 ppb = 1.6 d/m/ml
625 ppb = 1 d/m/ml
1 d/m/ml = $625 \times 7 \times 10^{-10}$ = 4375×10^{-10} = 44×10^{-8} µc/
=

nbe .2 d/m/ml $\cong$ 125 ppb
9-25-59 Beta .53 d/m/ml = 2.4×10^{-7} µc/ml
1.00 d/m/ml = 4.4×10^{-7} µc/ml

$10\ ppb = 1 \times 10^{-8}\ g\ of\ U^N / g\ of\ water$

$= 0.01\ \mu g\ U^N / g\ H_2O$

$$\frac{(2.5\times10^4\ d/s/mg)(1\times10^{-8}\ g\ U/g\ water)}{3.7\times10^{10}\ d/s\ /curie} = 0.7 \times 10^{-14}\ curies/g\ H_2$$

$= 0.70\times10^{-8}\ \mu c/g\ H_2O = 7\times10^{-9}\ \mu c/ml\ H_2O$

$U^N\ \alpha$

	Then: 1 ppb	$U^N \cong 0.7\times10^{-9}\ \mu c/ml$	$= 7\times10^{-10}\ \mu c/ml$ (1.6×10^{-3} d) Sr 90	
	15 ppb	$\cong 1\times10^{-8}\ \mu c/ml$	0.022 d/m/ml	
	150 ppb	$\cong 1\times10^{-7}\ \mu c/ml$	0.22 d/m/ml	MPC U_W continuous occ "Unknown"
1.5 ppm)	1500 ppb	$\cong 1\times10^{-6}\ \mu c/ml$	2.2 d/m/ml	
(15 ppm)	15,000 ppb	$\cong 1\times10^{-5}\ \mu c/ml$	22	300 ppm $\cong$ $2\times10^{-4}\ \mu c/ml$ $U^N\ \alpha\ \beta_{0}$ +
(150 ppm)	150,000 ppb	$\cong 1\times10^{-4}\ \mu c/ml$	220	
(1500 ppm)	1,000,000 ppb	$\cong 1\times10^{-3}\ \mu c/ml$	2220.	
15,000 "	15,000,000 "	$\cong 1\times10^{-2}\ \mu c/ml$	22,200.0	
~~150,000 "~~	150,000,000 "	~~$\cong 1\times10^{-1}\ \mu c/ml$~~	220,000.	
1,500,000 "	1,500,000,000 "	$\cong 1\times10^{0}\ \mu c/ml$	2,220,000.	

$10\ ppb = 7\times10^{-9}\ \mu c/ml$

$(7\times10^{-9}\ \mu c/ml)(3.7\times10^4\ d/s/\mu c) = 26\times10^{-5}\ d/s/ml$

$10\ ppb = 1.6\times10^{-2}\ d/m/ml$ $\quad (1\ ppb = 1.6\times10^{-3}\ d/m/ml)$

$1000\ ppb = 1.6\ d/m/ml$

$625\ ppb = 1.0\ d/m/ml = 45\times10^{-8}\ \mu c/ml$

mba
?-20-59

Mention Outline of points to be covered

START

Tennessee.....Public Acts of 1945....to regulate and control the pollution of the surface waters and streams of the State. "no substances in the waters which may produce toxic conditions that materially affect man, animals or aquatic life, or impair the potability of a treated water supply.

AEC.....Chapter 0524...."Permissible Levels of Radiation Exposure"....NCRP of NBS is responsible for setting standards;; ~~guides~~ AEC operations will maintain all the standards set by this organization. These shall be considered min. requirements.

SPP-310 Disposal of Waste Materials

The permissible levels of exposure for plant personnel are not satisfactory for those living or working in the neighborhood. All plant workers should realize the hazards involved in their jobs and in accpeitng a job, accept the hazards. This is true in any field and is not unique for those engaged in work with radiation. People outside the plant are not aware of the hazards and have not eneterëd into any agreement with the company. Therefore, every effort is made to see that their possible exposure is far below that allowed for plant personnel. (The limitation of exposure for those under 18, given in NBS Handbook 69, as one-tenth of that for adults, is an indication of the levels sought.)

The problem of health hazards involved in the discharge of uranium materials in the ORGDP wastes appears of minor consequence in view of the stringent limits desired from economical considerations.

Radioactive materials in rivers are ~~known to be~~ absorbed by biological organisms, absorbed on clay particles occurring as turbidity in streams, or precipitated by ~~other~~ either physical or chemical means, thus resulting in the accumulation of radioactive substances in the sediment. Naturally occurring radioactive isotopes of uranium thorium, and potassium account for 25% to 40% of the radioisotopes in the Clinch River and Tennessee Rivers; the remainder of the radioactivity is from fission products of which the most prominent are ruthenium, cesium, cerium.

(Map of Tenn. River)

(Map of ORO) ~~Objectives~~

(Map, ORGDP)

~~Objectives~~ "Sanitary Water Supply"

(Map, ORNL) (Photographs)

S&HP initiated lab requests and pay for analyses
Field sampling of mud and water performed by Utilities
Works lab handles requests and route samples to counting section asneeded.

Dilution of radioactive contaminats released from WOL depends on CR flow. Actual current flow and predicted future ~~flow~~ of water from Norris Dam ~~is~~ available with about a 2-day lag. ORNL has a policy of releasing only that amount of curies which will give below tolerance concentrations at the mouth of WOCreek. Thus below tolerance concentrations of radioactivity should prevail in the CR at the ORGDP water treatment plant, but experience has shown that the tolerance level is exceeded. Some explanation for this may be found in the wide variation in CR flow during a 24 hour period and the possibility that this variation may not be preperly accounted for in ORNL calculations.

Curie — that quantity of radioactive nuclide that disintegrates at the rate of 3.7 × 10¹⁰ d/second. (equivalent to 1 gram of radium

suggest the pilot policy relating to
disposal of liquids [illegible] in accordance
with applicable laws & regulations
to preclude ~~any~~ endangering persons
property and/or vegetation by such disposal.

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO LOCATION Health Physics File

DATE September 16, 1952

ATTENTION COPY TO Mr. A. F. Becher ✓

ANSWERING LETTER DATE

SUBJECT Flow Volume for Poplar Creek

On August 16, 1952, Mr. L. C. McWilliams of the U. S. Geological Survey Department stated that 2 water flow measurements had been obtained on Poplar Creek and East Fork. These were taken at periods of minimum flow.

1. Poplar Creek on Highway 61, 2 miles from Oliver Springs toward Oak Ridge.

   August 21, 1951 - 6.97 ft^3/sec.
   October 15, 1951 - 6.19 ft^3/sec.

2. East Fork on Oak Ridge Turnpike approximately 5 miles from Oak Ridge.

   August 21, 1951 - 18.0 ft^3/sec.
   October 15, 1951 - 15.2 ft^3/sec.

Since East Fork enters Poplar Creek upstream from K-25, the total flow at K-25 as indicated by these measurements was at least as follows:

August 21, 1951 - 24.97
October 15, 1951 - 21.39. 5×10^7 l/day

J. C. Bailey
J. C. Bailey
Health Physics Section

JCB:mh

M. Sandra 4-12 9-25-59

1958-1959 (Ave). East Fork Branch — 64×10^6 gallons/week
— 243×10^6 liters/week
— 35×10^6 liters/day
— 3.5×10^7 " "

[redacted]

[redacted]

INTER-COM[redacted]NY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

RECEIVED SEP 17 1952

TO Mr. W. L. Richardson (2)
LOCATION K-1001

DATE September 17, 1952

ANSWERING LETTER DATE

ATTENTION Mr. J. C. Bailey ✓
COPY TO File

SUBJECT Health Considerations Involved in SF Material Discard Limits

The problem of health hazards involved in the discharge of uranium materials in K-25 wastes appears of minor consequence in view of the limits desired from economic considerations, since it appears that any limit under approximately 240,000 ppm. of normal uranium or 2400 ppm. of product uranium at present plant release rates would be within the limits proposed by the AEC for such waste disposal.

No specific limit has been established by nationally recognized bodies for waste disposal. However, the Subcommittee on Internal Dose of the National Committee on Radiation Protection sponsored by the National Bureau of Standards has recommended a limit of 8×10^{-5} μc./cm.^{3} of water as the maximum permissible limit of uranium contamination for drinking water.[1] This corresponds to approximately 120 ppm. for normal uranium and to approximately 1.2 ppm. for K-25 product.

A proposed AEC policy governing allowable radioactivity in discharged wastes was enclosed in a letter of May 15, 1952, from Mr. S. R. Sapirie to Mr. C. E. Center. This proposal states that the "Average concentrations of waterborne radioisotopes at any point where the water is normally used for drinking by humans or by domestic animals used for food, or where the water is normally used for commercial fishing, shall not exceed 10% of the values recommended in National Bureau of Standards Handbook 52 for continuous use for periods less than 10^4 days."

Thus, if it were assumed that the water of Poplar Creek were subject to use as defined above, K-25 wastes should be so controlled that the average activity in the water at any point should not exceed approximately 12 ppm. for normal uranium or 0.12 ppm. for K-25 product uranium. It is apparent that minimum dilution of K-25 wastes is implicit in the above assumption; the Clinch River would afford additional factors of dilution.

According to the United States Geological Survey, the estimated minimum water flow of Poplar Creek is approximately 21 ft.^{3}/sec. or 5×10^7 liters/day.[2] Similarly, it is estimated that K-25 disposal of contaminated waste

1 U. S. National Bureau of Standards Handbook 52
2 Private communication from Mr. C. L. McWilliams of the Knoxville Office.

[redacted]

[redacted]

[redacted]

solution will amount to approximately 2.5×10^3 liters/day.[3] Thus, if a maximum concentration of 12 ppm. of normal uranium in Poplar Creek were permitted, the K-25 discharge rate could amount to approximately 240,000 ppm. Similarly, for material of product assay, a discharge concentration of approximately 2400 ppm. would be permissible.

It should be noted that if the quantities of waste disposal were increased, the allowable concentration would need to be proportionately decreased; similarly, if the quantity were decreased, the discard concentration could be increased.

It should also be noted that for enriched material, present K-25 specifications for criticality control require consideration to be given to solutions with a U-235 concentration above 1000 ppm.

In view of the relatively stringent requirements for limiting discard concentrations because of economic considerations, as given in KP-168, Part 43, "One Hundred and Ninth Meeting of the Uranium Accounting Committee, August 13, 1952", it seems that at this time factors involving health are of negligible importance.

Hugh F. Henry
H. F. Henry
Safety and Radiation Hazards

HFH:lja

3 Private communication from Mr. C. L. Gritzner, Chemical Operation Division, K-25.

[redacted]

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO Waste Disposal File

LOCATION

ATTENTION

COPY TO

DATE September 18, 1952

ANSWERING LETTER DATE

SUBJECT Calculations for Maximum Allowable Concentration of Uranium in Waste Solution

Assume a flow of 600 liters/sec. (21 ft^3/sec) and 70,000 liters of waste disposed per month or approximately 2500 liters/day which is the estimated amount of waste solution produced during recovery and decontamination operations. The flow in a 24 hr. period is 5.2×10^7 liters. For any assay uranium, the maximum permissible concentration in the waste solution is given by the relation

$$\frac{2500 \times c}{5.2 \times 10^7} = C$$

where

c = concentration in waste solution

C = Maximum permissible concentration in Poplar Creek

Thus

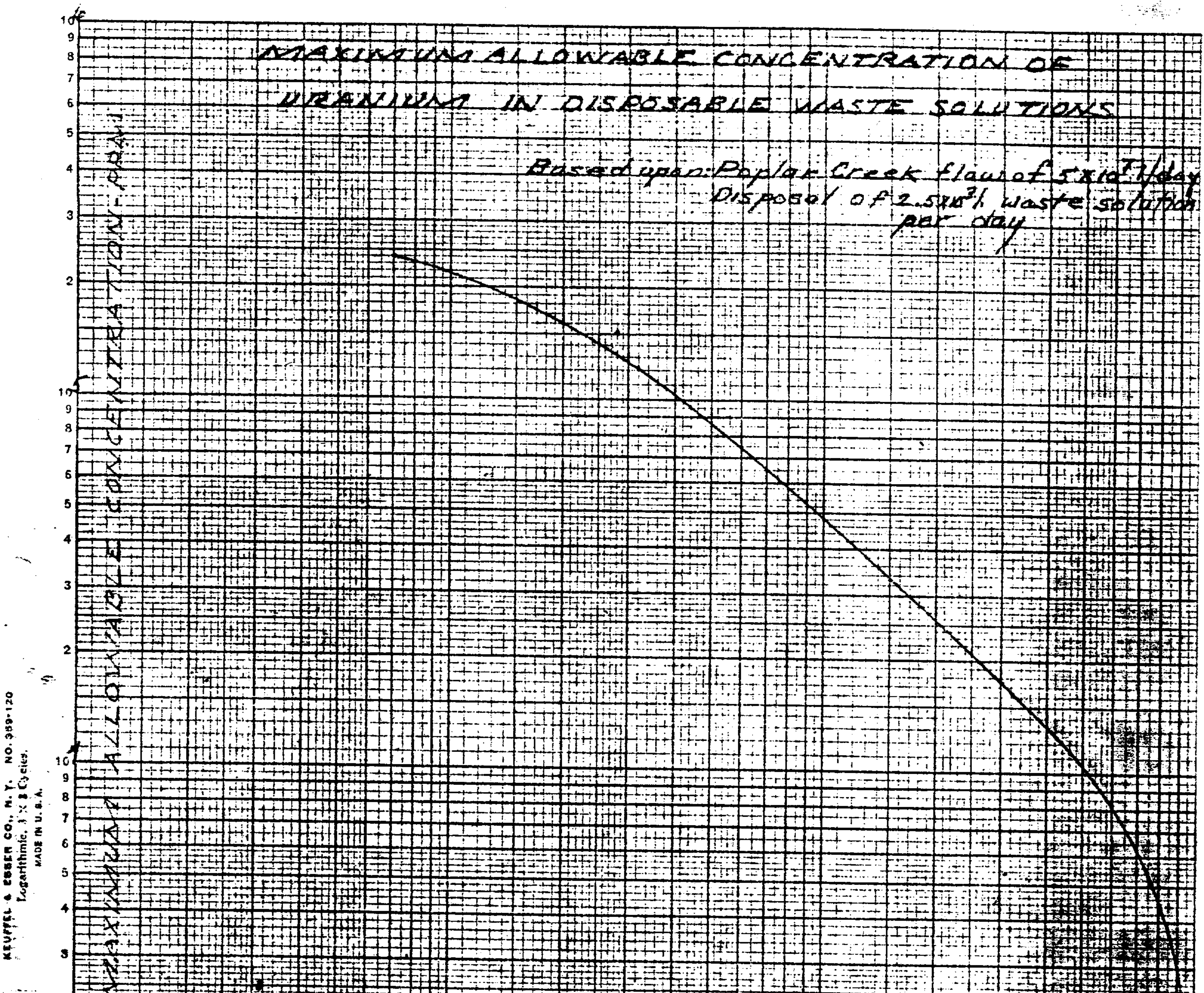
$$c = \frac{5.2 \times 10^7 \, C}{2.5 \times 10^3}$$

$$= 2 \times 10^4 \, C$$

For normal uranium this C is 12 ppm and hence c is 240,000 ppm.

J. C. Bailey
Health Physics Section

JCB:mh


MAXIMUM ALLOWABLE CONCENTRATION OF
URANIUM IN DISPOSABLE WASTE SOLUTIONS
Based upon: Poplar Creek flow of 5x10^7 l/day
Disposal of 2.5x10^3 l waste solution per day
MAXIMUM ALLOWABLE CONCENTRATION - PPM
ASSAY - % U-235
KEUFFEL & ESSER CO., N.Y. NO. 359-120
Logarithmic, 3 X 3 Cycles.
MADE IN U.S.A.

Recent Literature References

1. Purification + Concentration of Uranium in River Water Using An Ion Exchange Resin; GAT-L-197 —

2. Levels of Sr^{90} in Canada upto May, 1956 — Governments CRC -791

3. KL-17 Determination of Strontium-90 in Sanitary Water Oct. 15, 1958.

4. ORNL-2491; Development of a continuous ion exchange process for the removal and recovery of high-purity cesium from alkaline waste, Higgins, 11/7/58.

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6. P-1175 Disposal of the Radioactive Effluents at the "Commissariat A L'Energie Atomique" Treatment Leading to Evacuation to a River — MM. Duhamel (France) (In French)

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HW-57411

gross beta & alpha in reactor effluent and river sampled since 1945.

If gross is > MPC for any isotope present, must do isotopic —

$\frac{1}{20}$ to allow for limitations of sampling & analyses — delays between release & control feedback from measurements & evaluation, and for variable combinations of exposure from numerous sources to people at different locations in the environs.

Average River flow — 14.7 × 10⁵ gallons/second

Gross beta 6.45 × 10⁻⁶
total 5.07 × 10⁻⁶ (known isotopes)
Unaccounted 1.38 × 10⁻⁶

Cr^{51} (2.14 × 10⁻⁶), Cu^{64} (1.3), Na^{24} (0.9), Np^{239} (0.9), Mn^{56} (0.5), As^{76} (0.45), Zn^{69},
(La, Ce, Sm), Zn^{63}, Ga^{72}, Si^{31}, Sr^{91}, P^{32},
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continuous for 1 week sample — Sr, Ba, Ph
Pasco, Washington — (inlet pumphouse of city Water Dept.

discharge of reactor cooling water to Columbia River — diminished downriver by decay, diffusion in the river, dilution by springs + tributaries, and by sorption + metabolism on particulate material and aquatic organisms in the water.

Ion exchange — Amberlite XE-100

Results

$\mu c/ml$

1.7 × 10⁹ 10/27/55
~~6 × 10⁹~~ (Sr $^{89+90}$)
8.0 × 10⁹ 12/15/55

0.9 → 6.9 × 10⁹ Sr ^{89} (12/22/55 – 8/17/56)

1.0 → 6.9 × 10⁹ Sr ^{90} × 10¹⁰ (12/22/55 – 8/17/56)

1.1 – 14.0 × 10⁹ Ba ^{140} "

0.9 – 4.5 × 10⁸ P ^{32} "

November 10 through November 14, 1958 Number 46

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Radio-activity of plankton — 435 species compared with Columbia River

X-10 disposal pits IV 250 - 400 mr/hr. — almost at surface of seepage

no evidence adduced that radioactivity accounted for more than normal % dead insects crayfish, snakes + turtles. (not so constrictive as chem. composition ~~of~~ with water —

Exposed to 42,700 R dose — alive 1 year later.

Pits II + III 15-20 mr/hr. — July 56

settling basin White Oak Lake } same or lower.

Clinch

higher plankton content.
varied plankton
smaller volume of water.

Columbia -

diatom plankton predominates
radioactivity to mouth

Plankton concentrates on surface — Norris Dam intake is about 100' below surface — barren of plankton to White Oak Creek — water is cold, 12°C below dam

steep gradient to Callahan Bridge —

Disappearance of detectable radioactivity by Watts Bar Dam: dilution, mud + plankton incorporation

"Contributing some radioactive materials to the local environment and continuing vigilance must be maintained to determine the nature and extent of dispersion of these radioactive materaisl. The low degree of radioactive contamination of the air and water by CRGDP does not repres nt a hazard to the local enviornment or population".

To: Files, Water & Mud

Subject: Additional Information, ORNL Waste Disposal

submerged Geiger-Mueller tubes

Trebler Proportional sampler with revolving dipper

Holding Pits: 5 probes in parallel at entry of waste from processing labs into the holding pits. Cottrell says set about 38 c/m/ml (eff. not known) to automatically direct "low level" to settling pond or "high level" to treatment plant. "low" may come from any of numerous ORNL labs; "high" comes from dissolving of slugs. "Dipper" on sampler at settling pond effluent is cut proportional to water flow, as is the "v" weir. Samples every 10-12 minutes. Counter and alarm; sample runs out into metal drum; picked up every 24 hours; aliquot part saved for monthly composite (radio-isotopic); daily gross beta.

Branches: check for seepage; continual recorded flow; weekly grab sample. Flow on White Oak Creek checked just prior to confluence with Melton fork; grab sample daily as check against levels at dam. Same on Melton branch; this is usually background, unless decontaminating equipment at HRE.

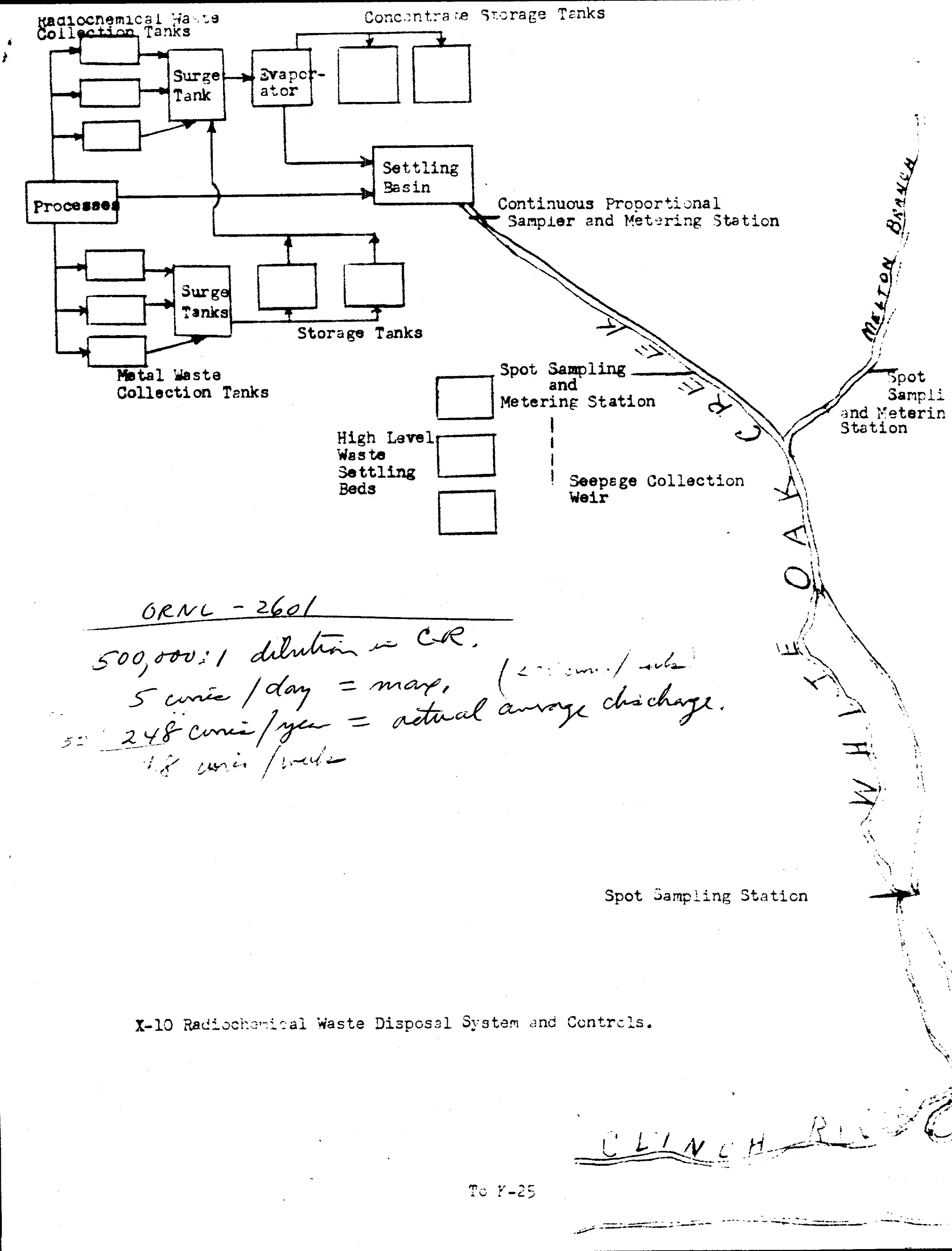
Wells: gamma probe is lowered at fixed rate; record manually readings and depth.

Dam: Presently split gate, manually operated. Long-planned-for canal not yet dug; discussion continues as to need; in case of release of slug, close dam and unless heavy rainfall, have time to dig canal for by-passing dam of White Oak Creek. Tenative plan to operate lake at 1/3 capacity, instead of White Oak Creek only; affords additional dilution. July: small lake is due to backwaters of Watts Bar. At dam sampling station: 1 mr/hr background at low water level; less with higher water level. Reading of scale units is telemetered back to Abee's office; pick up aliquot samples daily for gross beta; keep part for monthly composite. Alarms "about 10 divisions" on scale; value has not been calibrated; difference in proportion of isotopes passing out; different mev; average about 0.7 mev for beta. New monitor is ordered; more sensitive and dependable; plan to calibrate new installation.

4 liter
to
100 ml
to
chem l

High-level waste settling beds: Auerbach says 3 yr. study current on seepage or leakage. Davis says majority of authorities (TVA) feel breakdown of beds not likely, considering geological information. Some difference of opinions do exist on this subject, however.

ORNL-2601: CR concen: assumes intimate mixing with WOCr water; Scarboro minus Norris equals aver. flow at WOCr. High: level 7000gal/day; .001-0.02c/gal;
Low level: 700,000gal/day; 0.1 to 1.0 uc/gal; 1000x lower than reactors; 80-5200c/gal.
NBS:nbs Conasauga shale, containing clays; 20 underground tanks; 3 abandoned;
liquid waste now neutralized with caustic soda; 150c/min/ml alarms at ponds;
7/13/59 "flounder"; 12 battery-operated GM tubes in parallel; CR (a) dispersion in sediment; (b) levels of rad.; (c) rate of buildup; cross-section every 2 miles in CR; 10 miles in Tenn; 50' intervals. Kingston; daily sample pulled; composited for 3 months. Fish; no significance. WOCr to CR (1957) 397 curies. Weekly average (1957) 0.9x10^{-7}uc/cc in CR; MPC, 10^{-7}uc/cc; exceeded 28% of time. 1957: TRE, 29%; Ce, 3%; Ru, 15%; Zr, 5%; Cs, 22%; Sr, 21%. Sediment drops off after 20 miles from ORNL; background by Ru 150 miles. Max. at cross-section is 18x background. Ru-106 primarily noted in wells; MPC Ru 100x Sr90. MPC



ORNL - 2601

500,000:1 dilution in CR.

5 curie / day = max. ([illegible])

248 curies / year = actual average discharge.

4.8 curie / week

X-10 Radiochemical Waste Disposal System and Controls.

Storage Tanks - Low level waste materials are pumped from the various operating buildings or from portable tanks into the storage drums (of stainless steel) and the waste materials are held up for decay, neutralization, and concentration. The area under the tanks where any spill or leak from the tanks would collect and the processed material from the storage tanks drain into the settling pond. A maximum of 35 curies of activity is released over a period of a week.

The Settling Basin - Here, the material from the storage tanks flows through a series of basins where solids or precipitates and flocculates are settled out. The liquid then flows out through a weir system where the flow is metered and a proportional continuous sampler collects a monthly composite sample for a radiochemical analysis. The waste then flows into White Oak Creek.

White Oak Creek - The flow of the creek is measured and a daily spot sample is taken just prior to its confluence with Melton Creek.

Melton Creek - The stream flows from an area where 2 reactor development buildings are located. This stream flow is metered and a daily spot sample taken to check on the activity released from the reactor area.

White Oak Dam - The dam is no longer used for routine water impoundment; however, the back waters from Watts Bar Lake creates a relatively large body of water in the area which fluctuates considerably, making metering of the flow impracticable. A daily spot sample is taken at the dam site and a radiochemical analysis made of the monthly composite of the samples. In the event of an uncontrolled release of activity to the creek, the dam may be closed and the material can then be stored in the lake. Some consideration is being given to building a by-pass to route the stream around the lake and dam to give better control of the lake if storage is needed.

The Settling Beds for High Level Waste - Three settling beds for holding the high level radiochemical wastes have been built in series so that when one bed is filled, the liquid is decanted from the top into the next bed. Tests are still being conducted to see how effective the clay beds are in trapping out the various radiochemical waste materials. Some seepage has been noted from the beds and a weir has been built to hold the liquid for testing. No significant uncontrolled release of material from the beds to the White Oak Creeks has been experienced or is anticipated.

Clinch River - No routine sampling is made of the Clinch River. The metering of the flow of White Oak Creek and Melton Branch and also of the Clinch River is used to calculate the dilution by the Clinch of the known curies of radiochemical waste released from the Settling Basin.

GSH:msp
September 19, 1956

50,000 d/m/ml

Visit to ORNL; Saturday, April 4, 1959, Ed Struxness
"Low level" waste effluent, released at $1x10^{-3}$ or $1x10^{-4}$ uc/ml (Diluted by CR). "Intermediate level" waste effluent; 1-10 uc/ml. White Oak Lake, 55 acres. Dry since about 1956. Settling basins used since 1951. Radioactive salts of sodium nitrate, (complexes). 150,000 curies of Cesium, 100,000 curies of Ru, 15,000 curies of Sr. Shale does not sorb Ru; ORNL discharges 800,000 gallons of waste per day.

Hanford: condensates from boiling waste, trapped and released to "cribs"; 50-100 meters out from source; Pu, RE, Sr, Cs, Ru, NO_3 (most remote).

DISPOSAL AND CONTROL OF RADIOACTIVE LIQUID WASTE AT ORNL

Information Obtained From: H. H. Abee, and W. D. Cottrell

Information Obtained By: G. S. Hill, and J. J. Lane

Date: September 13, 1956

A. Methods of holdup of liquid waste:

High Level

Waste is pumped from processing labs to a series of three holding pits. Activity loss is by soil leaching and exchange. The contribution of activity to White Oak Creek is not known but considered to be negligible. Some seepage has been noted and a weir has been built to hold the water for testing.

Low Level

Reactor Waste

Consists of process cooling water and other low level wastes. This water is held in retention ponds indefinitely and by seepage and evaporation the water level is reduced. The radioactivity is entrained by soil exchange and leaching.

B. Monitoring Stations

Water:

1) Low level holding pond release.

2) White Oak Creek.

3) White Oak Dam.

4) Melton Branch.

5) Kingston (taken by the ferry operator).

Mud:

1) White Oak Dam.

2) Many points up and downstream in the Clinch River.

C. Methods of Sampling

Water:

1) One proportional sampling site located at the low level holding pond which is a dip sampler arrangement whereby about a pint of water is dipped out every 12 minutes and emptied into a 5-gallon can, a sample is withdrawn daily for measurements of radioactivity. Each day this can is dumped into another larger can (wash tub size) from which a monthly composite is taken for radiochemical analysis.

2) Spot samples taken daily and water activity measured at:

   a) White Oak Creek.

   b) White Oak Dam.

   c) Melton Branch.

3) Grab samples taken at Kingston by the ferry boat operator in mud stream at a depth of 25 feet. Samples taken daily, collected weekly and analyses made monthly.

Mud:

The instrument used by X-10 to obtain mud samples is entirely different from the one used at K-25. At ORGDP a metal cone, perforated at the apex is cast into the water and dragged along the bottom. X-10 has an instrument sometimes referred to as a "clam-shell digger".

D. Counting Methods

Water:

After evaporation of sample, the total beta activity is measured by a thin window GM counter. The results are expressed in counts/minute corrected to 10% geometry. Radiochemistry analysis is made for TRE and fission products expressed as per cent of total activity.

Mud:

Activity and radioachemical analyses made on dried mud samples. River bottom monitored for gamma activity by a probe developed at X-10. It consists of a probe made up of 12 oversized GM tubes arranged in series and connected to a recorder. It is called the "Flounder" and measurements obtained are called Flounder measurements in their reports. It derives its name from its flat appearance resembling a fish (Flounder).

It is lowered to the bottom of the river and the counts are recorded on a scaler in the boat. All betas are screened out by the water and plastic cover of the instrument.

E. Water travel time from X-10 to ORGDP

This is not known and probably extremely variable because of Norris release and "backing up" characteristics of water from Watts Bar. They estimate from 1 - 4 days.

F. Dilution of activity by White Oak Creek and Clinch River. This dilution is not known.

G. Down Stream Activity

Studies have been made only on mud samples collected monthly.

H. Release of Activity Into White Oak Creek

The maximum allowable release is set at 35 ? millicuries per week. This is controlled by an Operations Division and weekly activity release is reported to the Health Physics Division. The release of radioactive liquid waste into the holding ponds or tanks is made by the various processing groups more or less at their own discretion. In the event of a major or accidental release, the Health Physics Division is notified.

In case of buildup or accidental release into White Oak Creek or Clinch River, the Health Physics Division will notify the Shift Superintendent at ORGDP.

X-10 has no emergency plan in the event of a major release. However by closing White Oak Dam they can hold the release for a period of time (1 - 2 weeks) until a run off canal can be dug or until alternative measures can be put into operation.

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JJL:lja
9-20-56

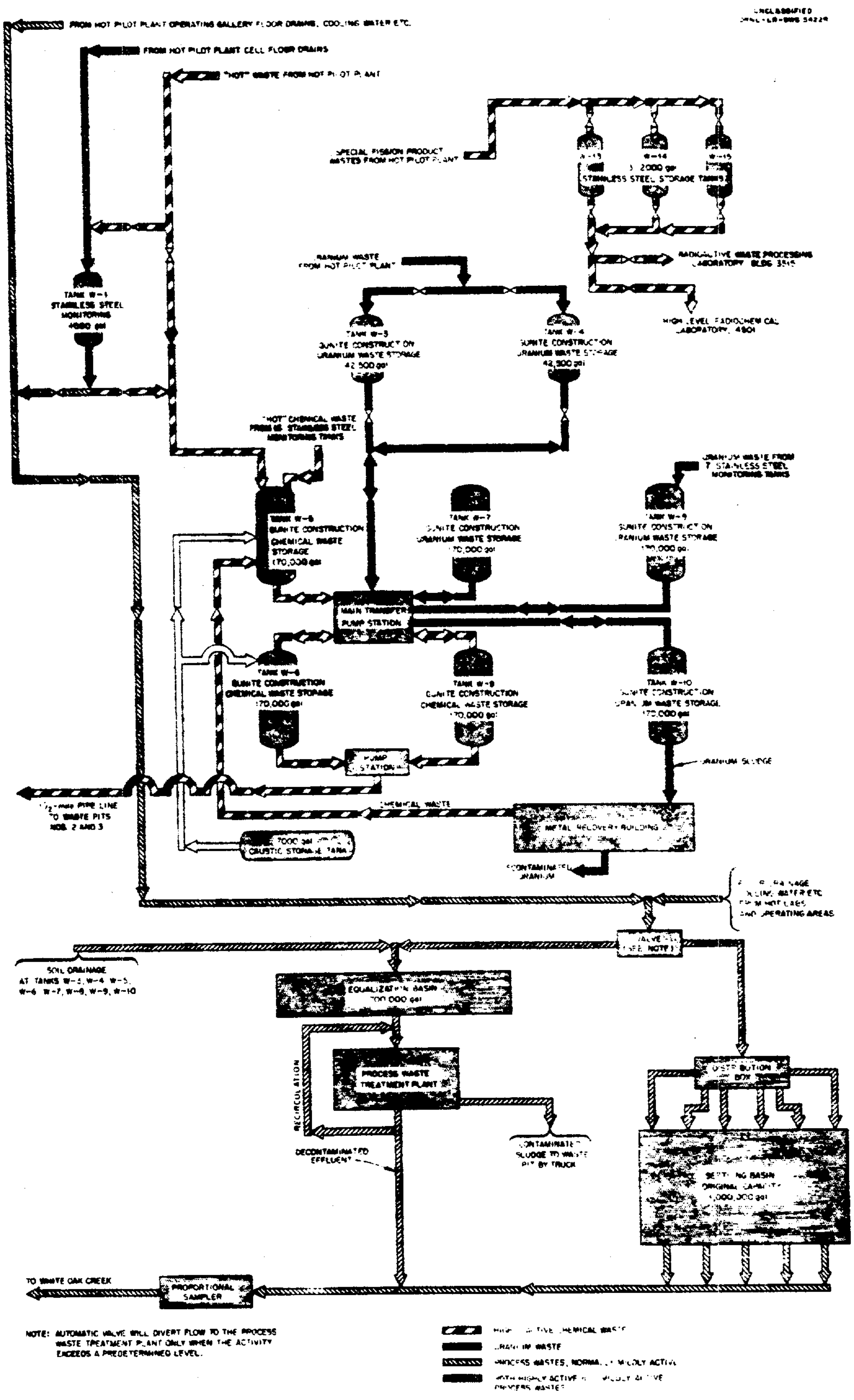


Fig. 3. ORNL Simplified Liquid Waste Disposal Flowsheet.

MAXIMUM PERMISSIBLE CONCENTRATIONS IN WATER

COMPUTATION OF MPC_W FOR MIXTURES OF RADIONUCLIDES

(Based on 10% of the MPC_W for 168 Hour Week Occupational Exposure)

1. Enter the percent of the total beta activity for each radionuclide as reported by "Radio Chemical Analyses of White Oak Lake Effluent" into the appropriate graph in Figures 1 or 2, and find the factor "N" for each radionuclide.

2. Find the arithmetic sum of these factors "N". (Σ N)

3. Enter this sum of "N" into Figure 3, and read the maximum permissible concentration in μc/cc for this mixture of radionuclides.

EXAMPLE

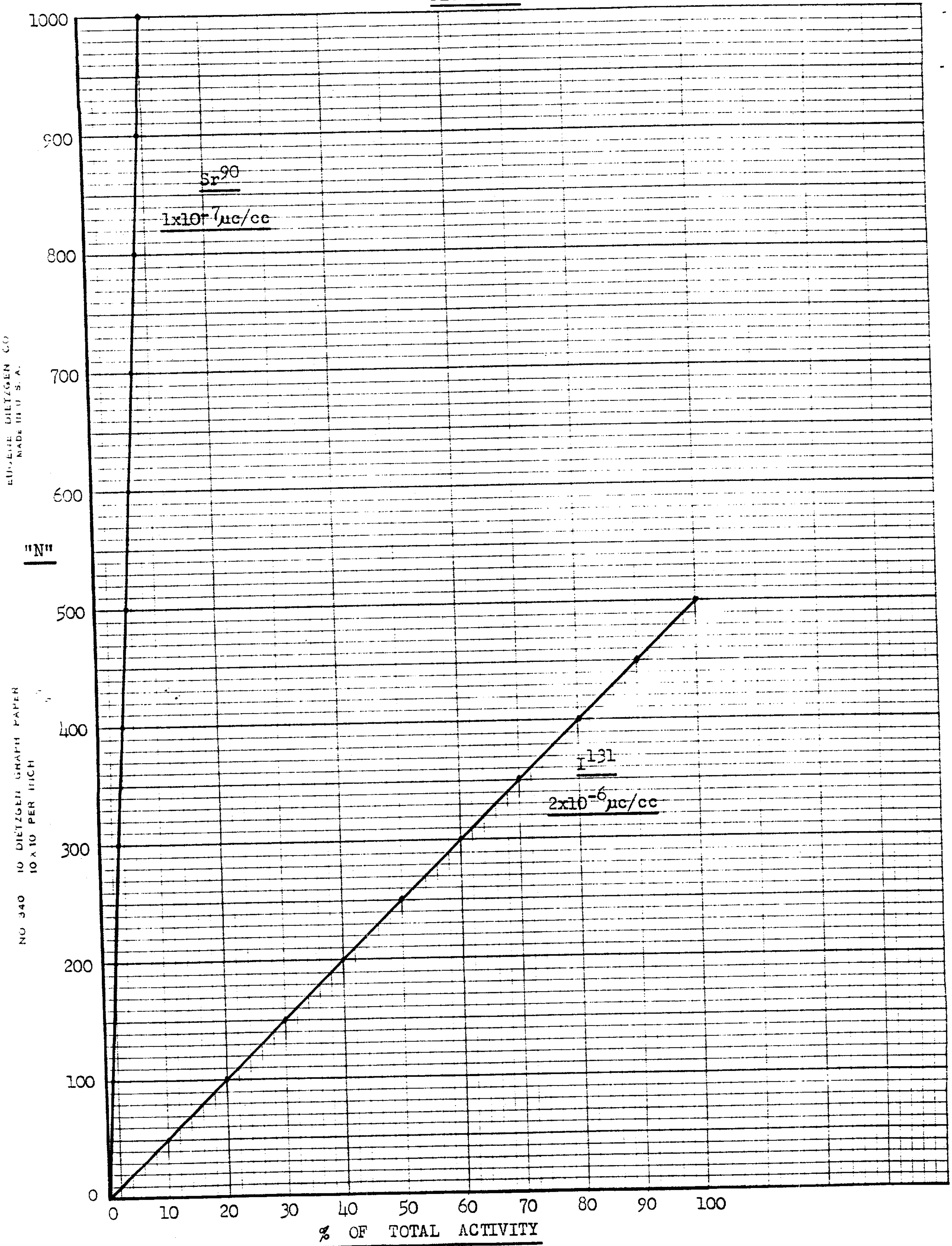
MARCH 1960

Radionuclide	%	"N"
Ru	88.4	88
Zr	0.4	<1
TRE	1.7	<1
Ce	1.1	<1
I	0.1	<1
Ce	2.2	2
Nb-Cb	0.0	0
Ba	0.07	0
Co	1.7	<1
Sr-89	0.2	<1
Sr-90	4.3	430
Sum of "N"	---	520
MPC_W-Mixture	1.92×10^{-6} uc/cc	

NBS:nbs

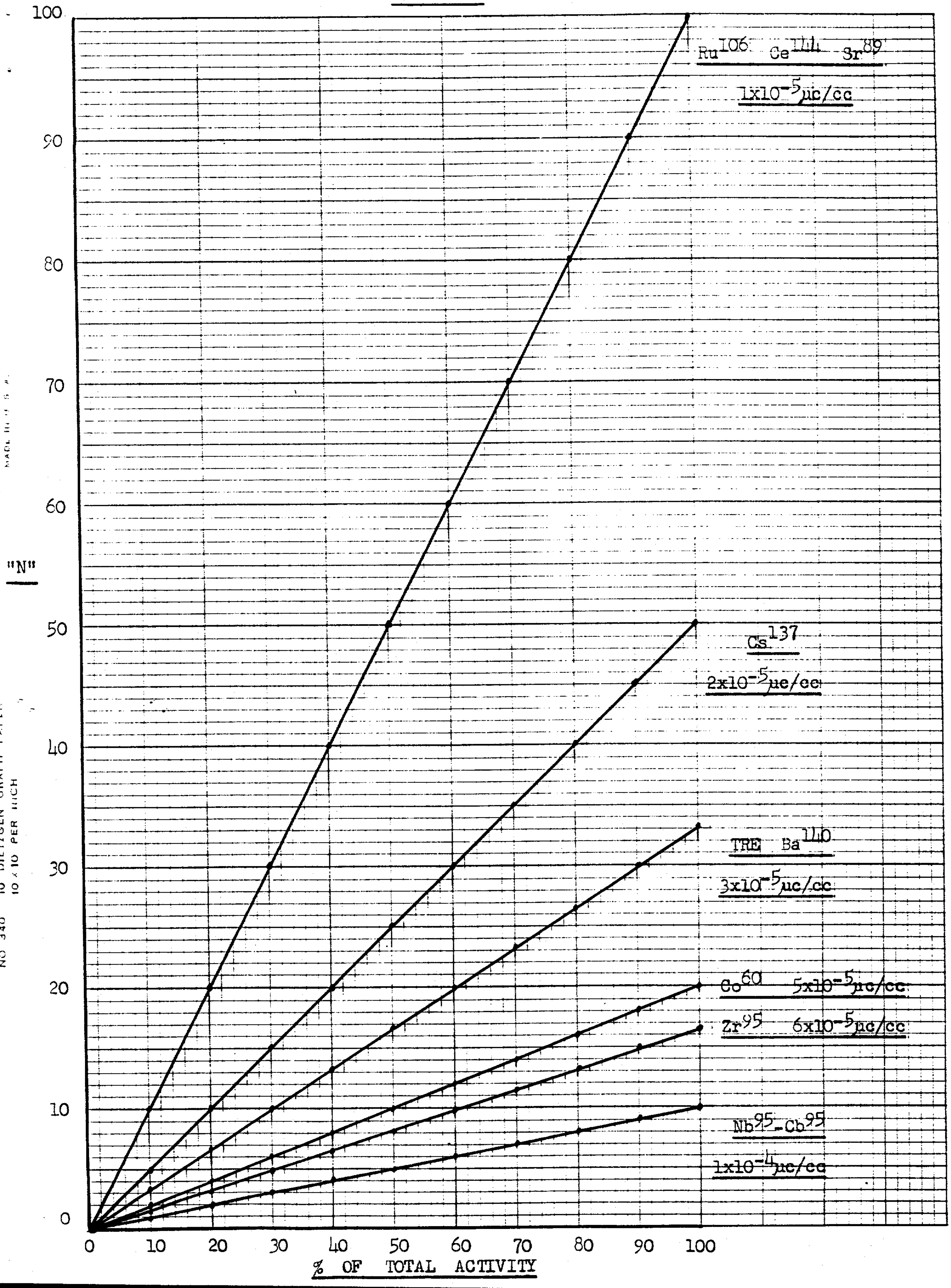
4/29/60

FIGURE 1



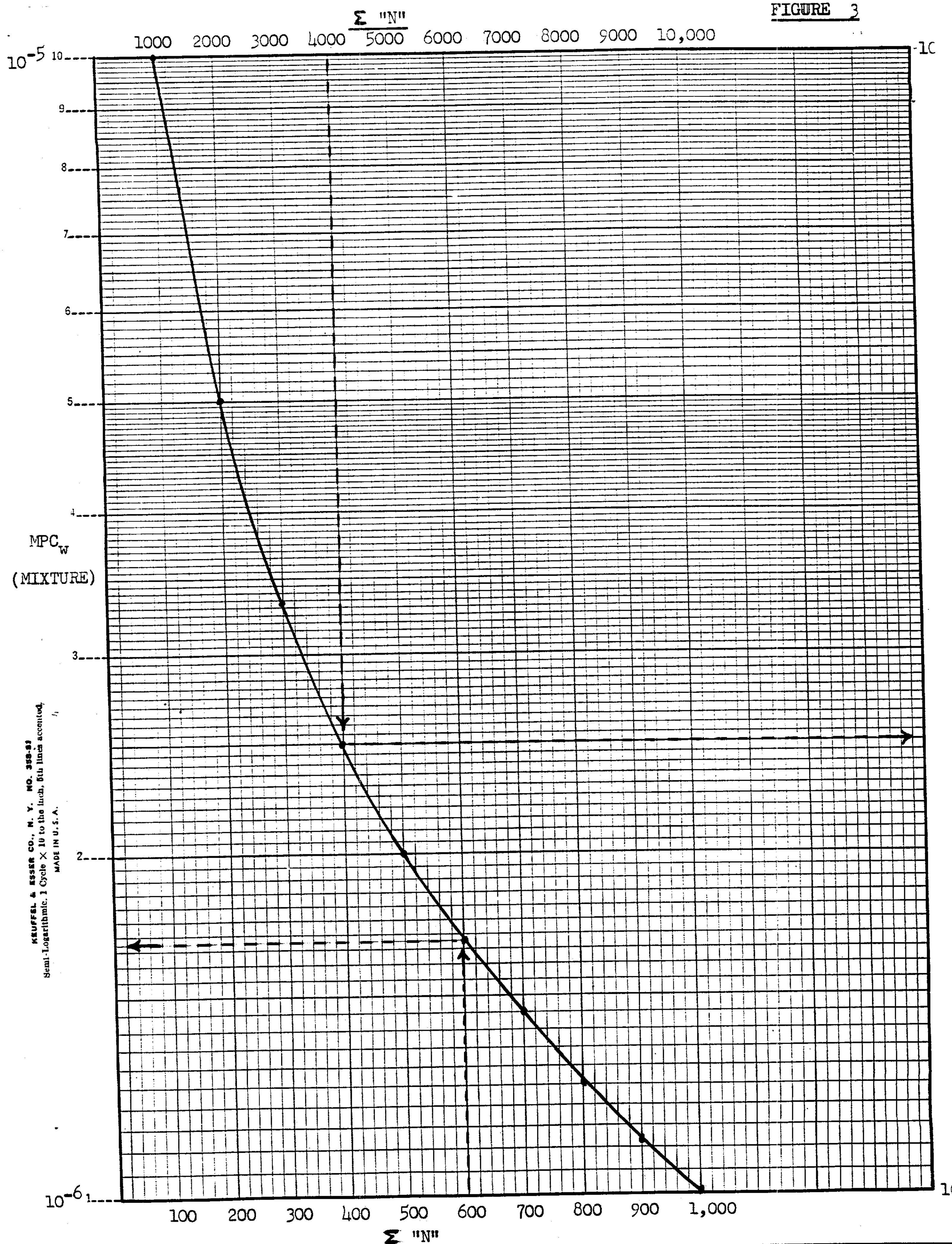
1000
900
800
700
600
500
400
300
200
100
0
"N"
Sr90
1x10-7 μc/cc
I131
2x10-6 μc/cc
0
10
20
30
40
50
60
70
80
90
100
% OF TOTAL ACTIVITY
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 340 10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

FIGURE 2



"N"
% OF TOTAL ACTIVITY
Ru106 Ce144 Sr89
1x10-5 µc/cc
Cs137
2x10-5 µc/cc
TRE Ba140
3x10-5 µc/cc
Co60 5x10-5 µc/cc
Zr95 6x10-5 µc/cc
Nb95-Cb95
1x10-4 µc/cc
0
10
20
30
40
50
60
70
80
90
100
NO 340 10 DIETZGEN GRAPH PAPER 10 X 10 PER INCH
EUGENE DIETZGEN CO. MADE IN U.S.A.

FIGURE 3



Σ "N"
1000 2000 3000 4000 5000 6000 7000 8000 9000 10,000
10⁻⁵
10
9
8
7
6
5
4
3
2
1
10⁻⁶
MPC$_W$
(MIXTURE)
100 200 300 400 500 600 700 800 900 1,000
Σ "N"
KEUFFEL & ESSER CO., N. Y. NO. 358-81
Semi-Logarithmic, 1 Cycle × 10 to the inch, 5th lines accented.
MADE IN U.S.A.

3-5330. Clinch River below Norris Dam, Tenn.

Location.--Lat 36°12'56", long 84°04'56", 0.5 mile upstream from Clear Creek, 1.0 mile downstream from Norris Dam, 1.5 miles north of Norris, Anderson County, and at mile 78.8.

Drainage area.--2,913 sq mi.

Records available.--October 1903 to September 1964. Published as "at Clinton" October 1903 to September 1927, and "near Coal Creek" May 1927 to September 1937. Records published for sites "at Clinton" and "near Coal Creek" May to September 1927; for sites "near Coal Creek" and "below Norris Dam" April 1936 to September 1937. Gage-height records collected in vicinity of Clinton from 1884 to 1943 are contained in reports of U. S. Weather Bureau.

Gage.--Water-stage recorder at present site and datum since Jan. 28, 1937 (digital since May 15, 1964). Datum of gage is 819.11 ft above mean sea level, datum of 1929, supplementary adjustment of 1936. Oct. 1, 1903, to June 30, 1920, staff gage at railroad bridge 19.6 miles downstream at datum 42.49 ft lower. July 1, 1920, to Sept. 30, 1927, chain gage at highway bridge 19.8 miles downstream (1,000 ft downstream from previous site) at datum 42.59 ft lower. May 27 to Sept. 8, 1927, staff gage and Sept. 9, 1927, to Sept. 30, 1935, water-stage recorder, at site 2.9 miles downstream at datum 10.50 ft lower. Oct. 1, 1935, to Sept. 30, 1937, water-stage recorder at site 2.9 miles downstream at datum 13.50 ft lower. Apr. 16, 1936, to Jan. 27, 1937, staff gage at present site and datum.

Average discharge.--61 years, 4,299 cfs (unadjusted).

Extremes.--Maximum discharge during year, 9,250 cfs on Apr. 8 (gage height, 5.87 ft); minimum, 58 cfs Sept. 9-11 (gage height, 1.22 ft), minimum daily, 62 cfs Feb. 12-14.

1903-64: Maximum discharge, 87,000 cfs Mar. 5, 1917 (gage height, 38.5 ft, from graph based on gage readings, site and datum then in use), from rating curve extended above 62,000 cfs; minimum, 1.3 cfs May 17, 18, 20, 24-26, May 29 to June 5, 1936 (gage height, 0.62 ft); minimum daily, 1.3 cfs May 17, 18, 24-26, May 29 to June 4, 1936.

Flood of Mar. 11, 1826, reached a stage of 43.5 ft (discharge, 130,000 cfs); floods of Feb. 24, 1862 and Mar. 31, 1886, reached a stage of 41.3 ft (discharge, 117,000 cfs) at railroad bridge at Clinton, from reports by Tennessee Valley Authority.

Remarks.--Records good. Flow completely regulated by Norris Lake (see p. 121).

Rating tables (gage height, in feet, and discharge, in cubic feet per second)

Oct. 1 to Feb. 16, Aug. 11 to Sept. 30				Feb. 17 to Aug. 10			
1.2	52	2.0	880	1.2	52	2.0	840
1.3	90	3.0	2,450	1.3	85	3.0	2,360
1.4	155	5.0	6,890	1.4	150	4.0	4,200
1.6	360			1.6	350	5.0	6,740

Discharge, in cubic feet per second, water year October 1963 to September 1964

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	6.020	4.560	78	3.720	4.040	654	6.200	95	3.700	3.150	2.840	* 4.030
2	*5.880	4.710	* 4.000	1.670	4.380	68	2.340	100	3.660	3.240	2.900	4.250
3	5.680	3.560	4.890	4.480	6.390	68	3.170	100	3.880	2.950	* 2.760	4.430
4	5.570	4.040	2.640	226	5.320	68	5.120	80	* 3.720	3.060	3.510	4.410
5	5.570	3.840	3.360	74	3.910	284	2.160	65	3.190	2.380	3.140	3.050
6	4.260	*1.110	4.580	74	1.350	341	927	65	2.790	* 3.150	3.230	1.720
7	5.090	4.060	5.450	74	2.070	68	95	65	2.650	2.990	3.300	2.670
8	5.640	4.200	3.960	735	1.680	68	983	65	2.880	2.940	3.620	3.990
9	5.610	3.610	5.070	254	66	68	561	65	3.280	3.020	2.650	2.450
10	5.690	2.250	5.880	772	4.710	2.260	85	65	3.370	3.060	2.900	638
11	5.720	3.660	108	78	752	294	85	2.730	3.490	2.960	4.080	2.740
12	4.220	3.900	884	78	62	68	85	3.640	3.420	809	3.560	4.110
13	3.940	3.450	78	3.770	62	65	90	*3.640	3.400	3.070	3.380	4.100
14	5.220	3.200	958	1.260	62	68	85	3.670	301	3.280	3.310	4.120
15	5.120	3.100	626	3.080	66	72	85	3.650	3.500	3.150	3.390	4.140
16	5.880	2.880	4.590	4.560	66	68	116	3.380	3.430	3.120	1.080	4.150
17	5.400	2.360	4.680	4.580	65	331	80	72	2.560	1.990	66	4.160
18	5.060	3.820	4.990	4.280	65	65	80	2.950	3.060	2.920	69	4.170
19	4.630	3.730	6.180	1.240	199	65	80	3.610	3.250	3.070	1.150	4.180
20	3.820	615	4.640	3.840	65	68	4.160	1.900	3.190	3.260	1.990	4.100
21	4.440	3.040	4.320	3.960	65	1.700	4.170	3.480	3.040	3.220	* 2.250	4.030
22	4.690	3.380	3.440	4.720	65	606	2.940	3.560	3.200	3.300	1.950	4.030
23	4.570	3.880	4.330	2.610	65	554	2.840	3.560	4.340	3.180	1.960	4.020
24	4.860	798	4.280	870	65	68	99	258	4.300	3.170	2.650	4.020
25	4.790	2.920	2.260	122	68	186	90	3.360	4.300	2.990	3.250	4.050
26	4.690	3.620	4.260	66	2.240	72	90	3.590	4.290	3.160	3.310	4.040
27	4.200	110	4.440	66	1.950	812	90	3.600	3.010	3.350	3.780	4.040
28	5.420	1.060	3.260	484	498	1.330	90	3.600	3.020	3.130	4.010	4.040
29	5.930	2.280	3.250	276	667	157	90	3.600	3.140	3.070	4.010	4.230
30	5.000	78	4.460	440	---------	2.160	90	303	3.320	3.280	3.850	4.350
31	4.620	---------	4.780	1.140	---------	* 5.710	---------	2.130	---------	2.900	3.840	---------
Total	157.230	87.821	110.722	53.599	41.063	18.466	37.176	61.048	98.681	92.319	87.785	112.458
Mean	5,072	2,927	3,572	1,729	1,416	596	1,239	1,969	3,289	2,978	2,832	3,749

Calendar year 1963:	Max	25,000	Min	46	Mean	4,382	Mean†	3,851	Cfsm†	1.32	In.†	17.95
Water year 1963-64:	Max	6,390	Min	62	Mean	2,618	Mean†	3,046	Cfsm†	1.05	In.†	14.23

* Discharge measurement made on this day.
† Adjusted for change in contents in Norris Lake.

3-5359.10. Clinch River at Melton Hill Dam, Tenn.

Location.--Lat 35°53'04", long 84°18'05" (corrected), at upstream face of Melton Hill Dam, at powerhouse on left bank, 5.4 miles north of Lenoir City, 9 miles southwest of Oak Ridge, 19 miles west of Knoxville, and at mile 23.1.

Drainage area.--3,343 sq mi.

Records available.--September 1936 to September 1964 (discontinued). Published as "near Wheat" September 1936 to January 1941 and as "near Scarboro" February 1941 to September 1962.

Gage.--Water-stage recorder. Datum of gage is mean sea level, datum of 1929, supplementary adjustment of 1936. Prior to February 1941 at site 8.6 miles downstream at datum 717.36 ft higher. February 1941 to September 1962 at site 15.9 miles upstream at datum 753.35 ft higher.

Average discharge.--28 years, 4,561 cfs (unadjusted).

Extremes.--Maximum discharge during year, 17,900 cfs Mar. 31; maximum elevation, 795.36 ft Oct. 21; no flow on many days.
1936-64: Maximum discharge, 42,900 cfs Feb. 9, 1937 (gage height, 23.45 ft site and datum then in use), from rating curve extended above 27,000 cfs; no flow on many days after April 1963.

Remarks.--Records fair. Flow regulated by Norris and Melton Hill Lakes (see p. 121).

Cooperation.--Recorder charts and experimentally determined spillway rating furnished by Tennessee Valley Authority.

Discharge, in cubic feet per second, water year October 1963 to September 1964

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	8,190	2,680	0	4,530	1,700	1,050	9,650	* 2,250	2,900	2,720	0	4,660
2	8,120	3,040	1,930	4,530	3,270	306	0	0	3,520	1,790	0	4,710
3	8,060	3,060	5,440	3,740	4,450	1,600	0	0	3,010	2,960	3,760	5,000
4	5,740	5,770	4,350	2,290	6,710	2,230	10,200	720	2,420	3,140	4,480	6,240
5	1,990	6,820	2,010	2,270	6,310	2,230	* 7,300	1,080	2,430	2,830	4,540	0
6	2,020	6,220	3,020	2,250	5,420	1,390	0	1,080	2,430	2,430	4,660	0
7	6,170	5,290	5,490	2,250	2,180	0	1,370	1,080	2,440	2,360	4,700	0
8	8,130	2,920	5,440	2,240	0	0	4,300	585	2,430	2,660	0	4,960
9	8,060	1,970	5,420	2,240	0	353	2,910	0	3,550	2,720	0	5,200
10	8,000	1,990	5,930	1,490	3,660	1,060	3,330	0	4,850	2,710	4,100	4,130
11	5,690	1,990	5,390	0	5,480	1,070	3,300	2,130	4,820	2,810	4,440	2,180
12	994	4,300	2,930	0	1,800	1,060	3,260	3,880	2,810	2,500	4,600	0
13	1,010	4,950	1,030	2,300	0	1,060	3,230	4,530	1,140	4,050	3,560	0
14	6,130	4,150	0	6,710	0	1,150	2,410	4,640	1,150	4,120	3,980	3,820
15	8,130	2,580	0	* 3,040	280	4,400	656	3,110	2,840	2,940	0	5,080
16	7,570	0	2,040	3,330	4,420	5,500	0	1,140	4,840	4,260	3,060	4,830
17	7,200	0	3,430	4,480	4,860	5,820	0	1,150	3,700	3,610	1,420	5,530
18	5,360	3,870	5,620	4,490	2,340	3,360	0	2,250	2,390	0	0	5,930
19	994	5,440	8,000	4,490	2,260	1,500	0	3,570	1,790	0	0	1,340
20	1,010	5,380	6,610	4,400	2,170	2,130	0	2,060	1,130	3,760	3,930	0
21	6,130	5,290	4,230	4,440	0	0	2,760	2,680	1,140	4,110	3,200	4,690
22	7,660	2,780	4,250	* 5,240	0	0	4,570	* 4,670	2,840	4,150	0	4,280
23	6,700	0	3,810	4,420	0	0	6,790	3,580	4,840	4,380	0	5,740
24	6,640	0	3,050	1,830	1,680	0	4,580	3,570	4,830	3,740	3,500	5,320
25	4,480	0	3,080	0	4,440	1,930	707	3,530	4,810	1,120	3,550	4,700
26	994	3,020	3,070	0	1,460	3,300	0	3,530	3,110	0	3,900	0
27	1,010	4,270	3,130	0	2,220	1,640	0	3,470	1,140	3,940	4,490	0
28	6,150	4,180	3,140	866	1,860	454	0	* 4,940	1,460	4,120	3,550	3,120
29	8,160	1,210	3,150	2,600	1,050	2,580	765	2,400	4,870	4,190	0	5,050
30	6,960	0	3,970	3,290	----------	360	675	2,400	4,840	4,300	0	5,400
31	5,510	----------	4,340	2,520	----------	10,300	----------	2,380	----------	4,020	5,000	----------
Total	168,962	93,170	113,300	86,276	70,020	57,833	72,763	72,405	90,470	92,440	78,420	101,910
Mean	5,450	3,106	3,655	2,783	2,421	1,866	2,425	2,336	3,016	2,982	2,530	3,397

Calendar year 1963:	Max 28,300	Min 0	Mean 4,804	Mean† 4,416	Cfsm† 1.32	In.† 17.93
Water year 1963-64:	Max 10,300	Min 0	Mean 3,000	Mean† 3,419	Cfsm† 1.02	In.† 13.92

* Discharge measurement made on this day.
† Adjusted for change in contents in Norris and Melton Hill Lakes.

3-5380. Whiteoak Creek at Whiteoak Dam, near Oak Ridge, Tenn.

Location.--Lat 35°53'58", long 84°19'34", at Whiteoak Dam on State Highway 95 (White Wing Road), 0.6 mile upstream from mouth, 2 miles south of Oak Ridge National Laboratory, Roane County, and 8 miles south of Oak Ridge, Anderson County.

Drainage area.--6.01 sq mi.

Records available.--July 1953 to September 1955, August 1960 to June 1964 (discontinued).

Gage.--Water-stage recorder. Datum of gage is 740.00 ft above mean sea level, datum of 1929, supplementary adjustment of 1936. Since Aug. 24, 1960, auxiliary gage on downstream side of dam.

Average discharge.--5 years (1953-55, 1960-63), 13.5 cfs.

Extremes.--Maximum discharge during period October 1963 to June 1964, 196 cfs Mar. 15; minimum, 5.0 Oct. 6-9, June 28, 29.
1953-55, 1960-64: Maximum discharge, 669 cfs Dec. 29, 1954; no flow at times in 1953-55, 1963.

Remarks.--Records good. Flow affected by operations of Oak Ridge National Laboratory above station.

Discharge, in cubic feet per second, period October 1963 to June 1964

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5.3	7.0	11	13	10	11	12	15	16			
2	5.1	7.8	8.1	13	8.8	*13	11	14	14			
3	5.2	6.2	*6.9	*11	*8.0	22	10	22	9.3			
4	5.3	5.7	6.4	13	7.2	19	13	16	7.4			
5	5.2	7.6	6.1	14	7.0	32	14	13	6.5			
6	5.0	11	6.0	17	19	25	26	11	6.5			
7	5.0	7.6	5.7	63	20	19	121	9.9	6.2			
8	5.0	6.4	6.4	38	15	15	87	9.0	6.2			
9	5.0	5.9	6.1	46	12	13	40	8.4	6.4			
10	5.1	5.9	5.9	33	11	14	25	7.6	6.1			
11	5.2	5.9	6.5	20	11	12	19	8.0	5.9			
12	5.2	5.6	13	19	9.2	10	15	8.8	5.7			
13	5.2	5.5	10	35	14	9.3	32	11	5.7			
14	5.2	5.3	8.6	23	22	26	44	8.8	5.7			
15	5.3	5.5	7.2	*16	45	*160	29	7.4	6.6			
16	5.6	5.5	6.4	13	92	*78	21	6.9	8.0			
17	5.6	5.3	6.1	11	*43	38	17	6.4	6.6			
18	5.5	5.2	5.9	9.9	33	25	15	6.2	6.4			
19	5.3	5.9	6.0	9.0	31	20	13	6.5	6.2			
20	5.3	6.0	6.0	12	*23	19	12	6.6	6.1			
21	5.6	6.1	6.0	11	18	28	11	6.8	5.9			
22	5.7	6.1	6.0	9.2	15	25	9.8	6.8	5.6			
23	5.9	8.2	6.6	8.6	13	20	14	6.6	5.6			
24	6.5	7.4	6.4	16	12	16	25	6.5	5.7			
25	6.4	6.5	6.1	63	11	21	18	6.4	5.7			
26	6.2	6.4	6.1	33	10	85	15	6.1	5.5			
27	6.0	6.6	6.4	*21	9.3	49	30	8.3	5.2			
28	6.0	7.0	6.5	15	11	29	30	15	5.1			
29	5.3	33	6.1	12	12	21	25	14	5.0			
30	5.3	19	6.0	11	----------	16	18	9.2	5.1			
31	5.5	----------	6.1	10	----------	14	----------	6.9	----------			----------
Total	169.0	233.1	212.6	638.7	552.5	904.3	771.8	295.1	201.9			
Mean	5.45	7.77	6.86	20.6	19.1	29.2	25.7	9.52	6.73			

Calendar year 1963:	Max	411	Min	0	Mean	13.1
Water year 1963-64:	Max	-	Min	-	Mean	-

* Discharge measurement made on this day.

3-5382.25. Poplar Creek near Oak Ridge, Tenn.

Location.--Lat 35°59'55", long 84°20'23", on right bank 1,000 ft upstream from county road bridge, 0.4 mile downstream from Indian Creek, 1.2 miles northwest of intersection of State Highway 95 and Anderson County line in Oak Ridge.

Drainage area.--82.5 sq mi.

Records available.--August 1960 to September 1964.

Gage.--Water-stage recorder. Datum of gage is 743.50 ft above mean sea level, datum of 1929, supplementary adjustment of 1936.

Extremes.--Maximum discharge during year, 2,880 cfs Apr. 7 (gage height, 18.27 ft); minimum, 5.0 cfs Oct. 27; minimum gage height, 1.89 ft Sept. 10.

1960-64. Maximum discharge, 6,350 cfs Mar. 12, 1963 (gage height, 22.38 ft); minimum, that of Oct. 27, 1963; minimum gage height, 1.86 ft Sept. 1, 1962.

A flood on June 29, 1928, at site about 5.0 miles upstream (drainage area, 55.9 sq mi) was the greatest known since at least 1900, from reports by Tennessee Valley Authority (discharge, about 14,000 cfs).

Remarks.--Records good except those for periods of no gage-height record or shifting control, which are fair.

Rating table, except periods of shifting control (gage height, in feet, and discharge, in cubic feet per second)

1.8	5.0	7.0	405
1.9	7.0	10.0	810
2.2	17	15.0	1,840
2.8	46	17.0	2,350
4.0	126		

Discharge, in cubic feet per second, water year October 1963 to September 1964

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	9.7	10	36	119	127	94	148	206	83	11	12	9.1
2	8.5	15	24	149	106	102	131	180	75	13	10	7.9
3	8.5	13	* 21	95	92	* 208	120	232	41	13	8.5	7.3
4	7.9	13	19	121	85	230	180	* 159	* 35	11	71	7.3
5	7.6	15	17	133	84	982	200	136	30	11	44	7.0
6	7.6	17	15	* 141	* 246	452	376	116	28	10	24	7.0
7	7.6	13	14	850	315	282	1,560	101	26	9.7	13	6.8
8	* 7.6	12	16	354	242	217	1,960	91	23	11	11	6.4
9	7.6	11	20	434	191	189	555	83	22	12	10	6.2
10	7.6	11	20	347	169	217	345	76	21	10	9.1	6.0
11	7.6	10	20	209	155	167	257	74	19	9.7	12	6.0
12	7.3	10	58	196	127	150	212	82	17	13	31	6.0
13	6.8	10	57	310	216	135	447	73	17	21	12	5.8
14	* 7.0	10	38	229	458	379	704	62	17	15	9.4	5.6
15	6.8	11	29	167	508	2,260	395	56	16	11	9.1	5.4
16	6.8	10	28	136	1,360	* 1,370	275	50	16	9.7	182	5.4
17	6.6	10	28	114	527	449	218	46	14	9.1	164	* 5.4
18	6.4	10	25	103	422	303	180	42	14	8.8	* 53	6.6
19	6.4	12	a 24	93	402	226	153	38	14	8.8	30	9.4
20	6.2	12	a 24	83	301	214	134	36	13	9.1	22	12
21	6.2	12	a 24	110	228	283	118	32	12	9.7	17	17
22	6.0	12	a 23	95	193	242	108	30	12	10	16	8.5
23	6.4	14	a 25	89	159	211	164	30	* 12	11	75	6.2
24	6.4	15	a 25	128	141	183	251	32	12	13	36	6.2
25	6.4	15	a 23	* 1,010	127	288	322	29	11	9.1	21	6.0
26	6.2	13	a 21	470	115	999	416	26	11	8.8	15	5.6
27	6.2	12	a 21	* 263	106	555	696	32	10	8.5	13	6.4
28	* 6.2	11	a 24	203	112	343	609	47	10	10	12	7.9
29	6.2	98	a 25	147	108	251	406	68	11	27	11	148
30	6.2	82	a 26	128	---------	* 203	270	36	11	32	10	109
31	7.0	---------	a 28	118	---------	168	---------	30	---------	22	10	---------
Total	217.5	519	798	7,144	7,422	12,352	11,910	2,331	653	388.0	973.1	459.4
Mean	7.02	17.3	25.7	230	256	398	397	75.2	21.8	12.5	31.4	15.3
Cfsm	0.085	0.210	0.312	2.79	3.10	4.82	4.81	0.912	0.264	0.152	0.381	0.185
In.	0.10	0.23	0.36	3.22	3.35	5.57	5.37	1.05	0.29	0.17	0.44	0.21

Calendar year 1963: Max 4,630 Min 6.0 Mean 121 Cfsm 1.47 In. 19.88
Water year 1963-64: Max 2,260 Min 5.4 Mean 123 Cfsm 1.49 In. 20.36

Peak discharge (base, 1,800 cfs)

Date	Time	Gage height	Discharge	Date	Time	Gage height	Discharge
3-15	1700	18.00	2,740	4-7	2400	18.27	2,880

* Discharge measurement made on this day.
a No gage-height record.
Note.--Shifting control method used Oct. 1 to Nov. 29, Jan. 26 to Feb. 15, Sept. 12-30.

3-5382.5. East Fork Poplar Creek near Oak Ridge, Tenn.

Location.--Lat 35°57'58", long 84°21'30", near left bank, on upstream side of county road bridge, 0.3 mile north of State Highway 95, 1.7 miles upstream from Bear Creek, and 2.8 miles southwest of intersection of State Highway 95 and Anderson County line in Oak Ridge.

Drainage area.--19.5 sq mi.

Records available.--August 1960 to September 1964.

Gage.--Water-stage recorder. Datum of gage is 754.16 ft above mean sea level, datum of 1929, supplementary adjustment of 1936.

Extremes.--Maximum discharge during year, 975 cfs Apr. 7 (gage height, 7.75 ft); minimum, 16 cfs Oct. 28, 30, 31; minimum gage height, 1.67 ft Sept. 6.

1960-64: Maximum discharge, 1,800 cfs Mar. 12, 1963 (gage height, 10.91 ft); minimum, that of Oct. 28, 30, 31, 1963.

The flood of Sept. 29, 1944 reached a discharge of about 4,600 cfs at a site 5.1 miles upstream. The flood of June 29, 1928 is believed to have been the greatest known flood since at least 1900, from report of Tennessee Valley Authority.

Remarks.--Records good. Natural flow of stream affected by operations of the Atomic Energy Commission's Y-12 Plant and the sewage treatment plant of the City of Oak Ridge.

Rating tables (gage height, in feet, and discharge, in cubic feet per second)

Oct. 1 to Aug. 16				Aug. 17 to Sept. 30			
1.7	16	3.0	135	1.7	18	2.0	34
1.8	20	5.0	440	1.8	21	2.5	80
2.0	32	6.0	616				
2.5	75						

Discharge, in cubic feet per second, water year October 1963 to September 1964

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	* 24	29	28	63	34	34	* 40	55	* 66	* 23	20	20
2	22	27	26	43	30	* 41	40	53	37	26	19	19
3	22	18	* 25	39	* 28	60	37	84	30	21	19	19
4	22	18	23	52	29	52	53	* 51	27	20	51	19
5	22	25	22	45	28	138	55	43	27	18	44	19
6	21	41	22	* 63	87	71	93	39	26	18	25	19
7	22	22	22	217	58	57	* 458	38	24	19	24	18
8	22	22	24	78	45	48	182	37	24	24	22	19
9	22	21	22	130	41	45	93	34	24	20	20	19
10	22	20	22	71	41	51	73	32	24	20	21	19
11	22	20	25	52	40	40	59	34	24	20	28	19
12	22	20	47	62	36	37	52	37	24	38	26	19
13	21	21	28	103	68	35	130	46	24	37	22	19
14	* 22	22	26	59	70	116	118	31	22	22	20	19
15	21	22	24	46	183	* 496	73	28	24	21	21	19
16	20	21	22	40	279	142	62	27	24	21	147	19
17	21	20	23	38	94	83	52	26	22	21	65	19
18	20	21	22	37	98	66	46	26	22	21	* 31	20
19	20	24	22	32	84	54	46	25	22	20	26	21
20	18	21	21	44	67	59	41	25	22	20	23	20
21	19	22	20	34	57	101	38	24	21	26	* 22	20
22	19	21	20	31	49	66	37	24	22	21	21	20
23	19	35	23	29	44	55	54	30	22	21	25	20
24	19	22	22	56	42	49	63	30	21	25	21	19
25	19	20	22	190	39	93	46	26	20	20	20	19
26	19	22	23	70	37	208	53	24	20	19	20	19
27	18	22	26	52	35	92	126	34	20	19	20	19
28	* 18	21	26	44	41	69	85	35	19	20	20	25
29	18	115	24	38	38	57	93	36	20	24	20	70
30	18	38	23	34	----------	48	65	26	20	31	20	44
31	18	----------	23	34	----------	44	----------	25	----------	20	20	----------
Total	632	793	748	1,926	1,822	2,607	2,463	1,085	744	696	903	659
Mean	20.4	26.4	24.1	62.1	62.8	84.1	82.1	35.0	24.8	22.5	29.1	22.0

Calendar year 1963:	Max	1,140	Min	18	Mean	44.2
Water year 1963-64:	Max	496	Min	18	Mean	41.2

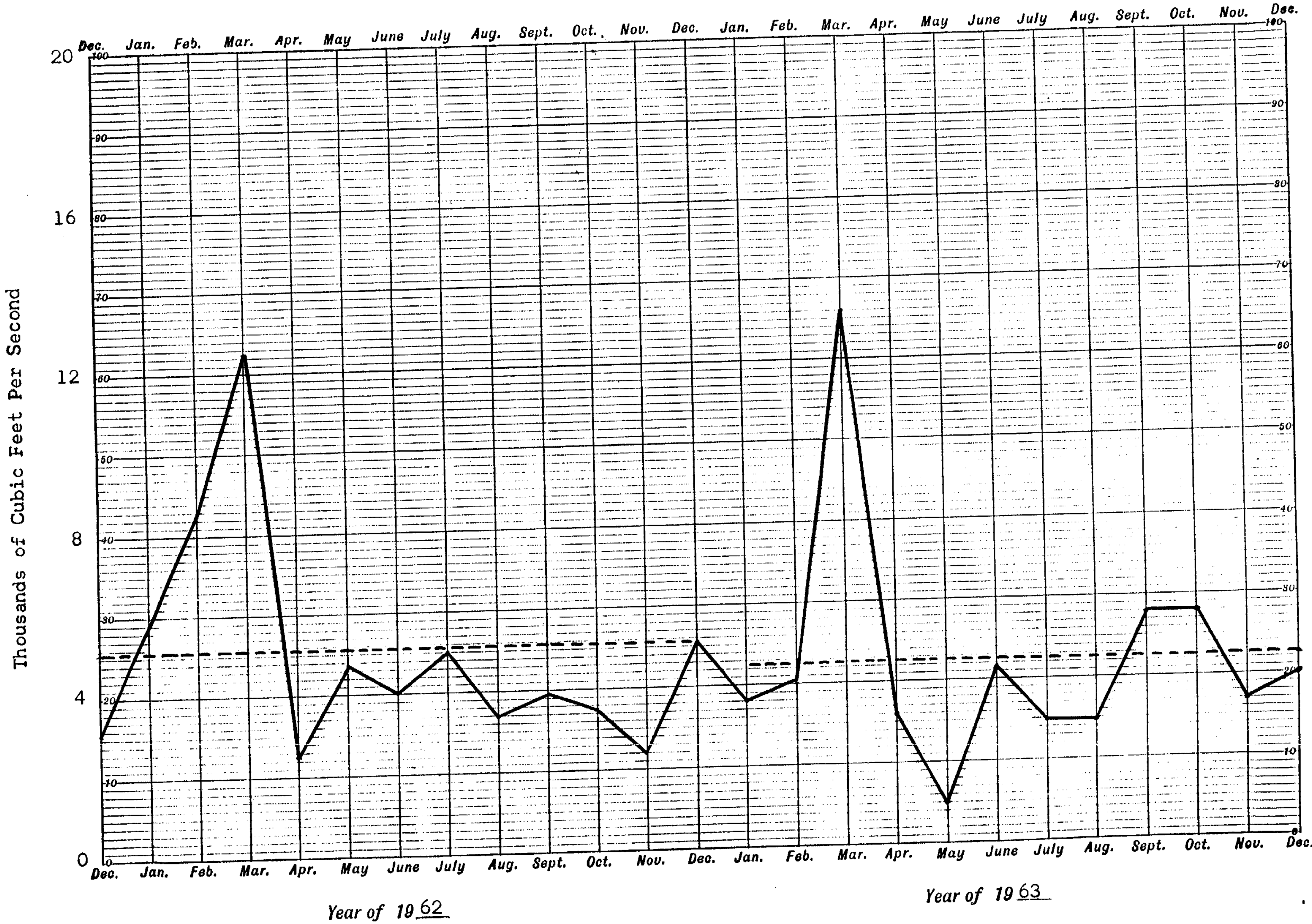
Peak discharge (base, 500 cfs)

Date	Time	Gage height	Discharge	Date	Time	Gage height	Discharge
2-16	0200	6.47	708	4-7	1700	7.75	975
3-15	1100	6.41	696				

* Discharge measurement made on this day.

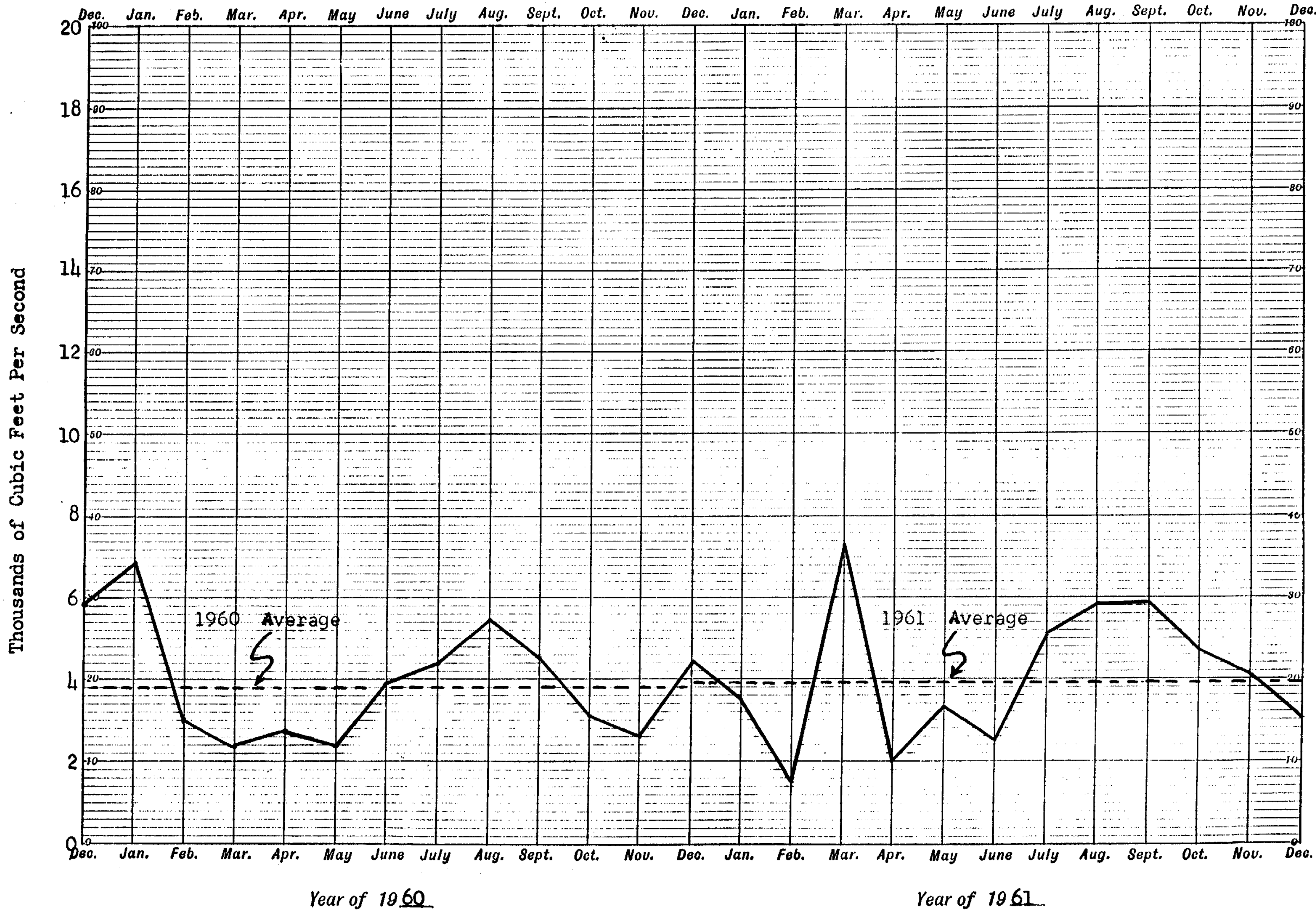
NORRIS DISCHARGE

(Average Cubic Feet Per Second)



NORRIS DISCHARGE

(Average Cubic Feet Per Second)

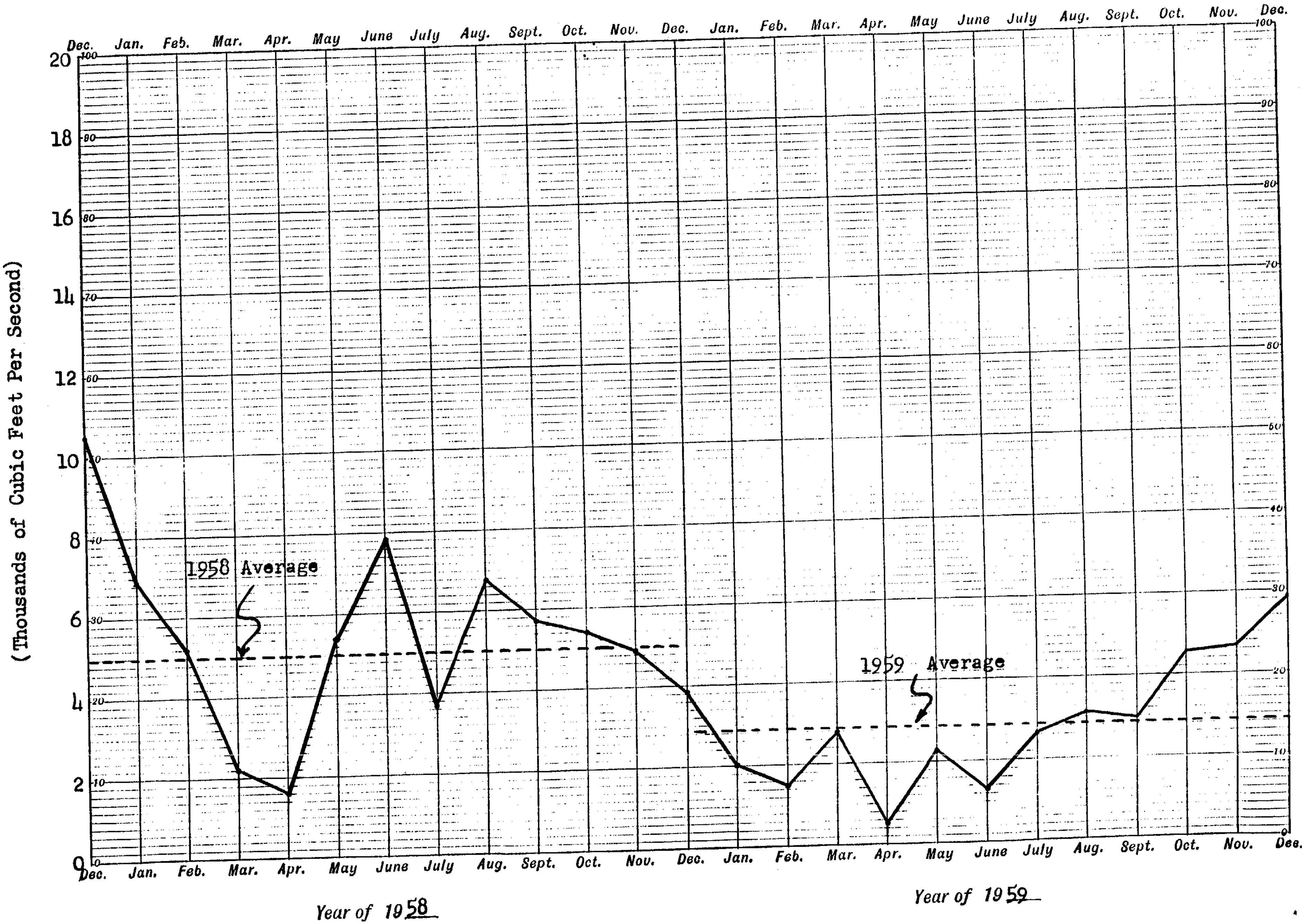


NO. 3250. TWO YEARS BY MONTHS X 100 DIVISIONS.

PRINTED IN U.S.A.

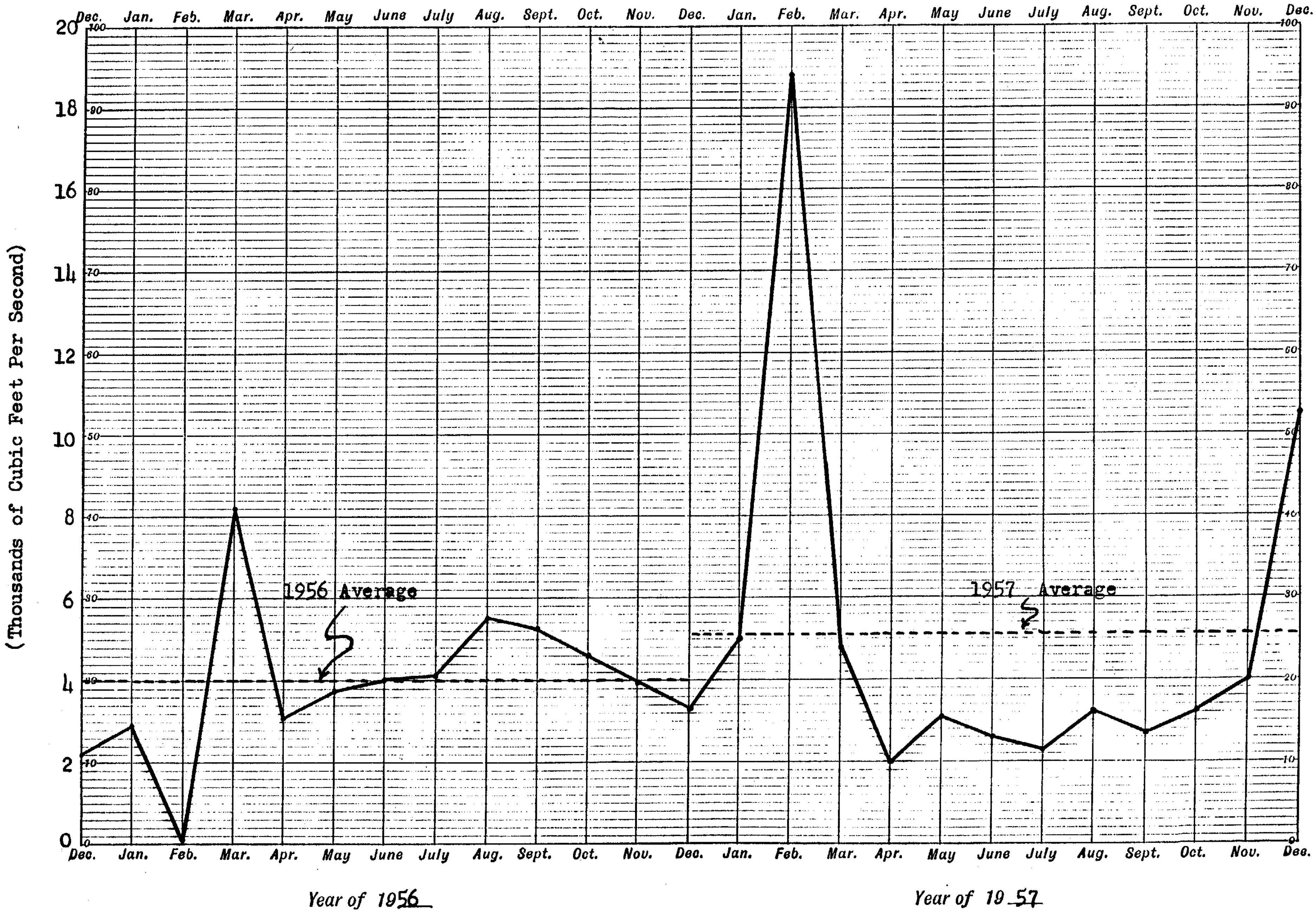
NORRIS DISCHARGE

(Average Cubic Feet Per Second)



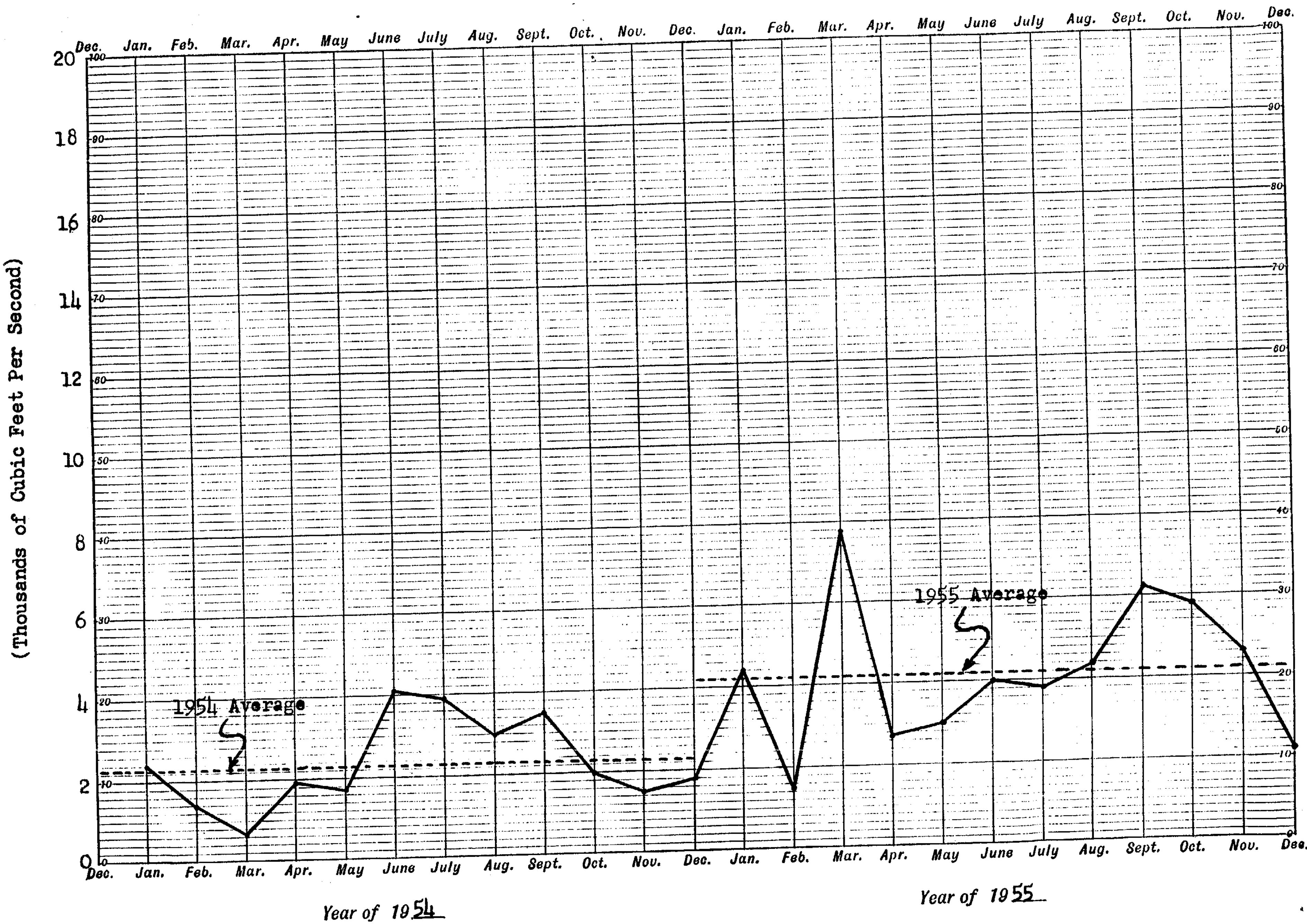
NORRIS DISCHARGE

(Average Cubic Feet Per Second)



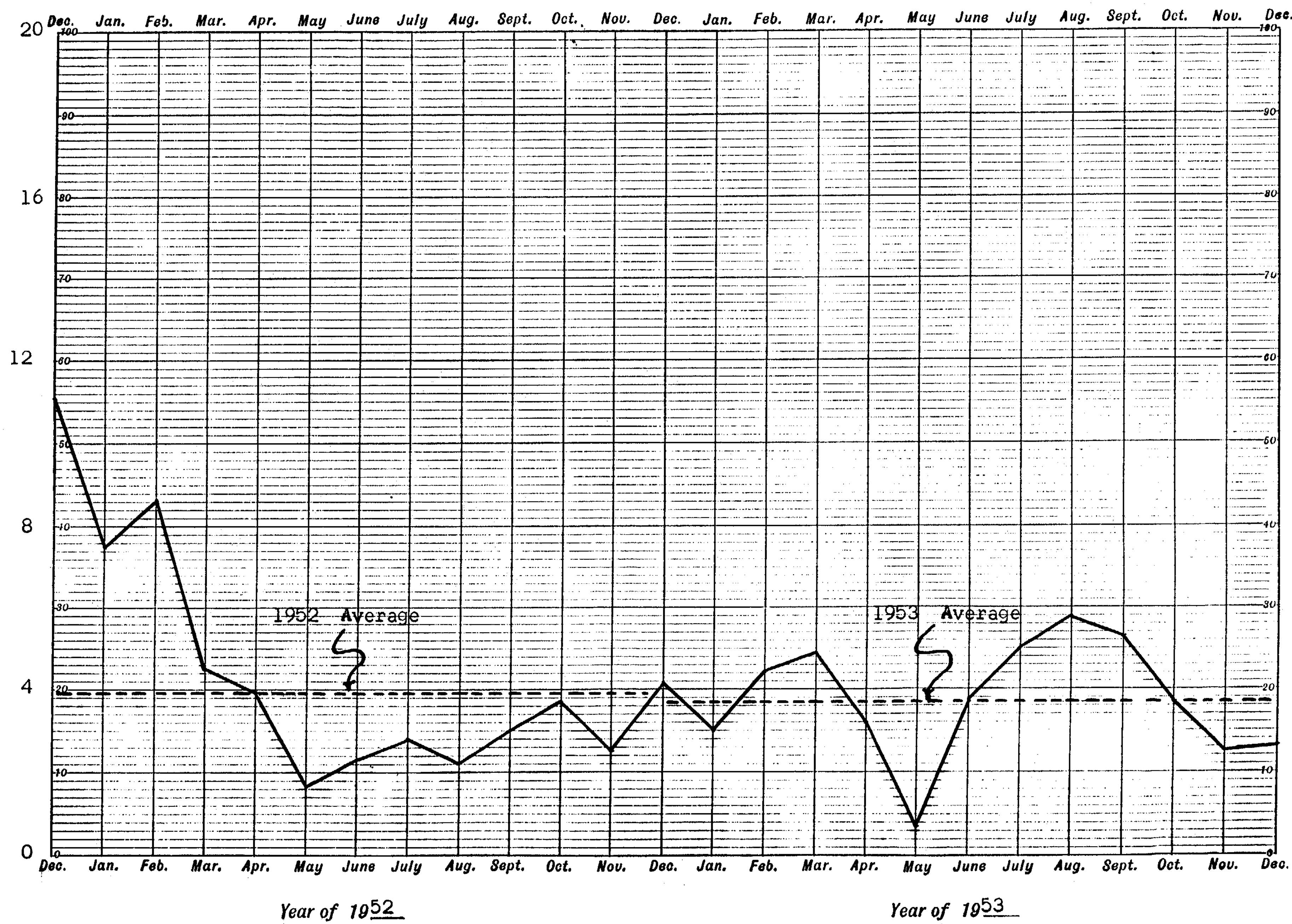
NORRIS DISCHARGE

(Average Cubic Feet Per Second)



NORRIS DISCHARGE

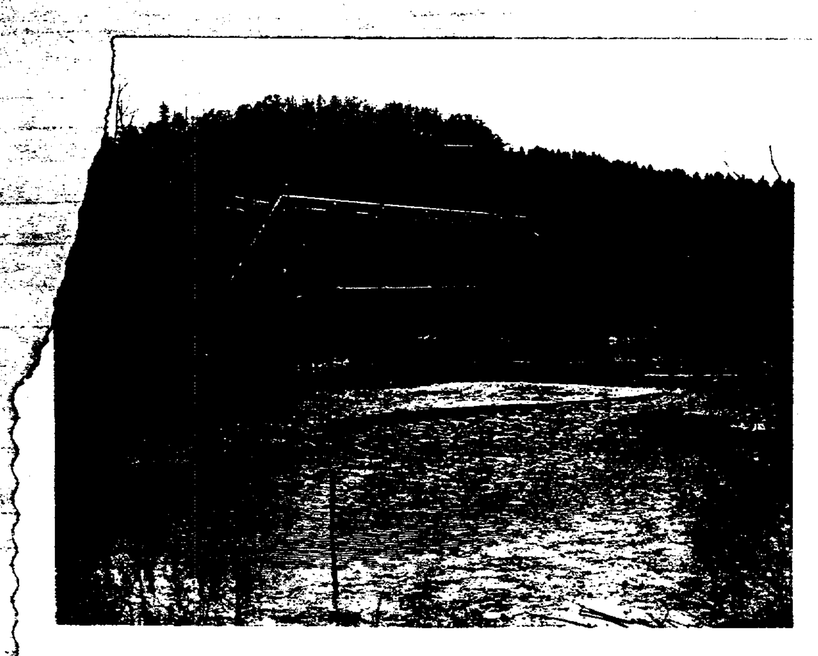
(Average Cubic Feet Per Second)



ORGDP Environmental Sampling

(Water)

CW-1 East Fork of Poplar Creek
near jct. with Main Branch
(Y-12 contribution)

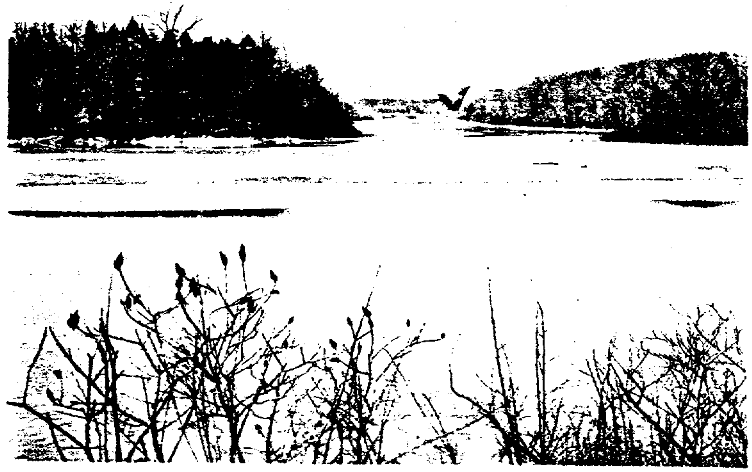


CW-8 Main @ West Branch
Poplar Creek

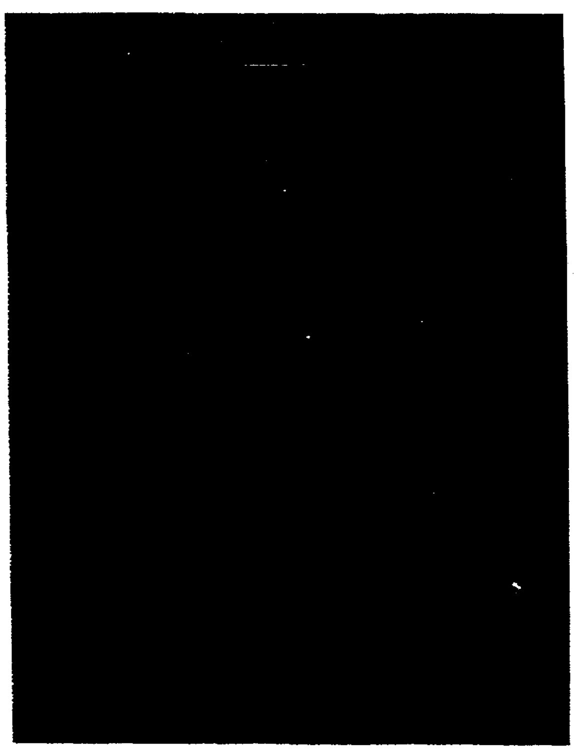
"Background" for
Poplar Creek

ORGDP ENVIRONMENTAL SAMPLING

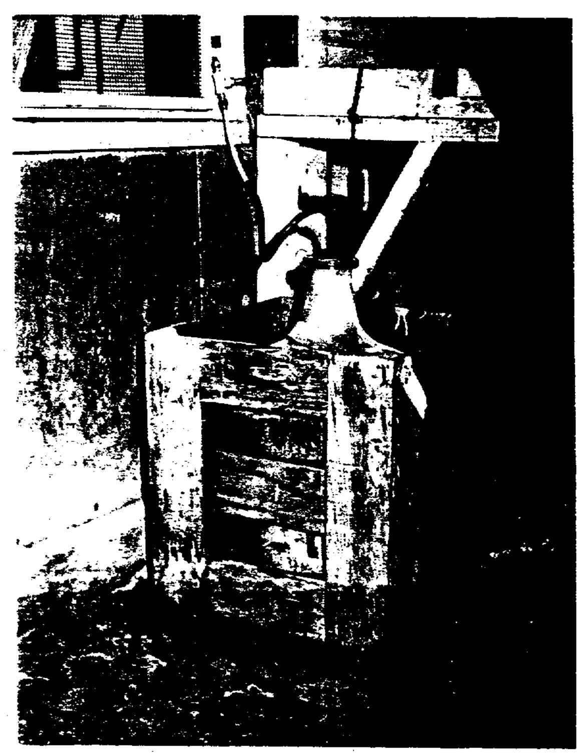
(Water)



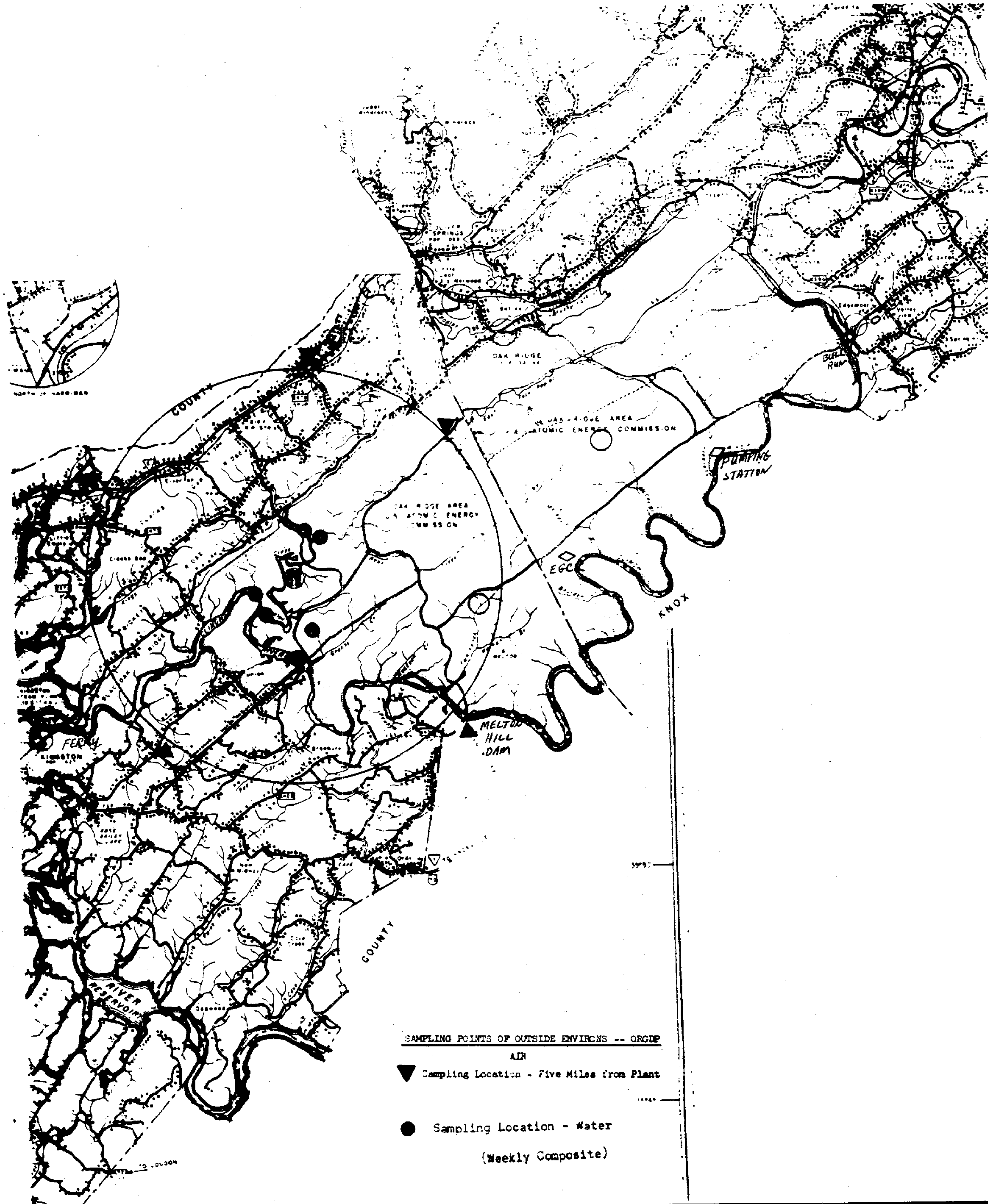
CW-3 Poplar Creek At Junction With Clinch River



CW-5 Sanitary Water Pumphouse Influent
"Raw Water"



CW-6 Effluent From ORGDP Water Purification Pla
"Finished Water"



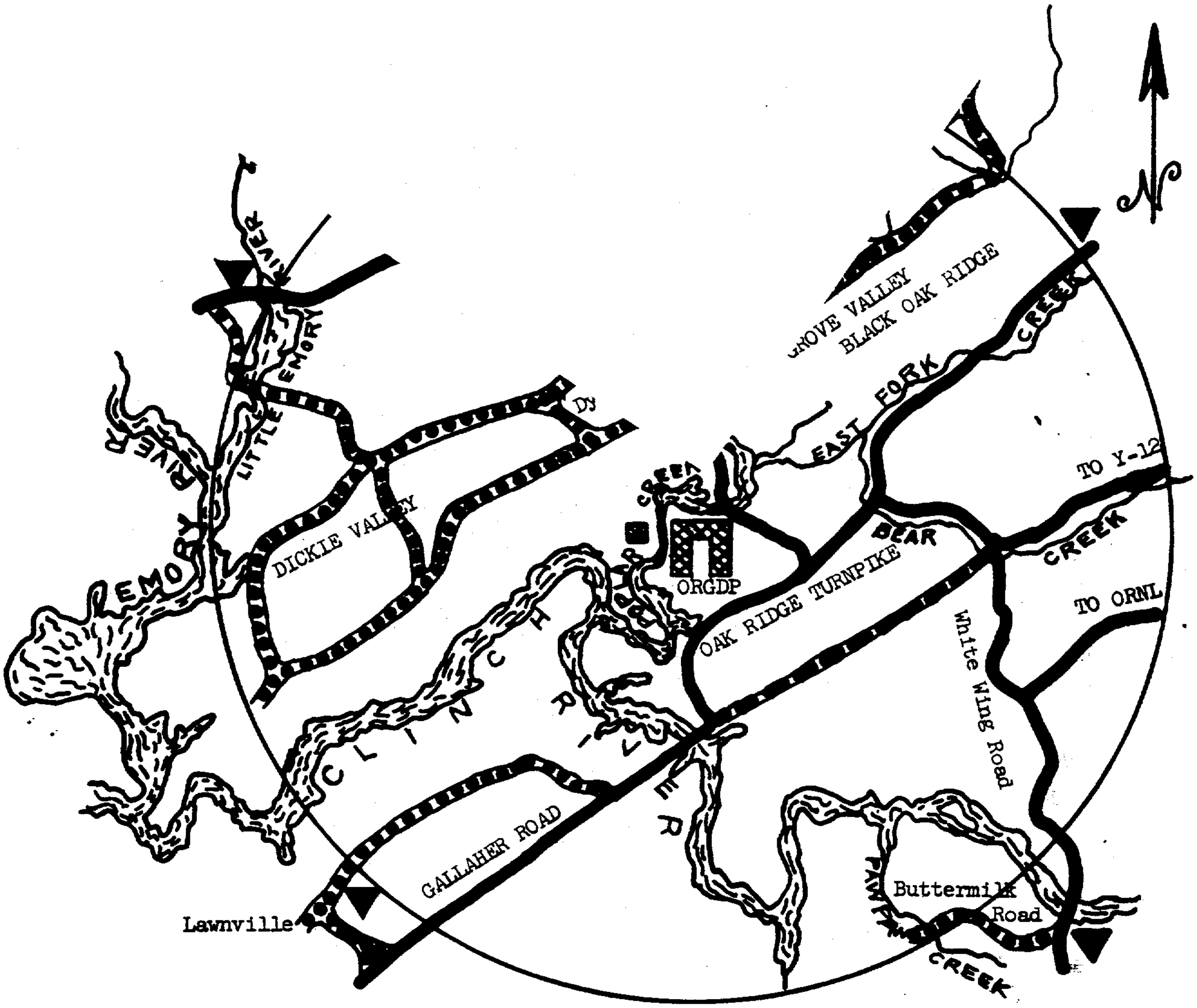
SAMPLING POINTS OF OUTSIDE ENVIRONS -- ORGDP

AIR

▼ Sampling Location - Five Miles from Plant

● Sampling Location - Water

(Weekly Composite)

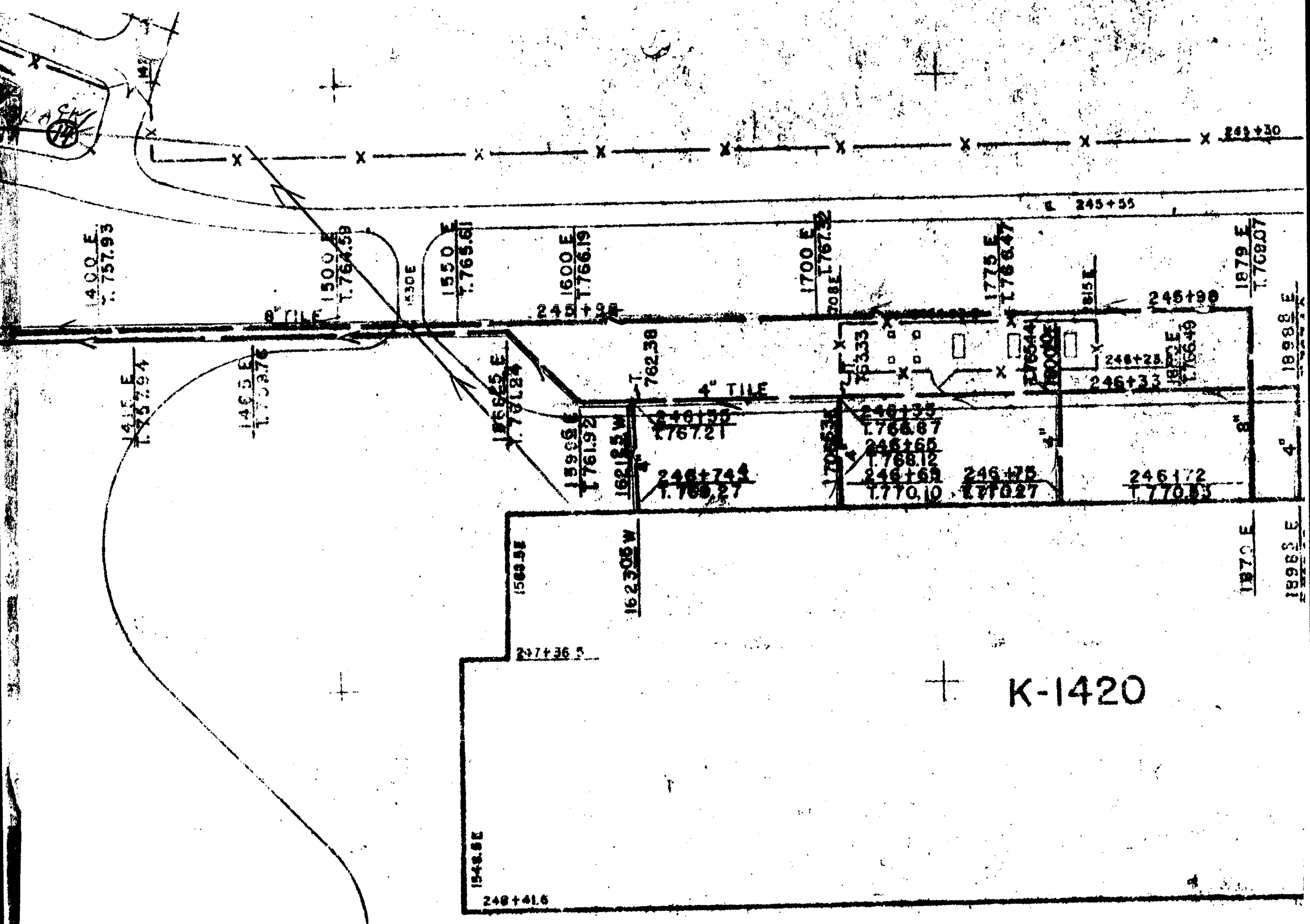


SAMPLING POINTS OF OUTSIDE ENVIRONS -- ORGDP

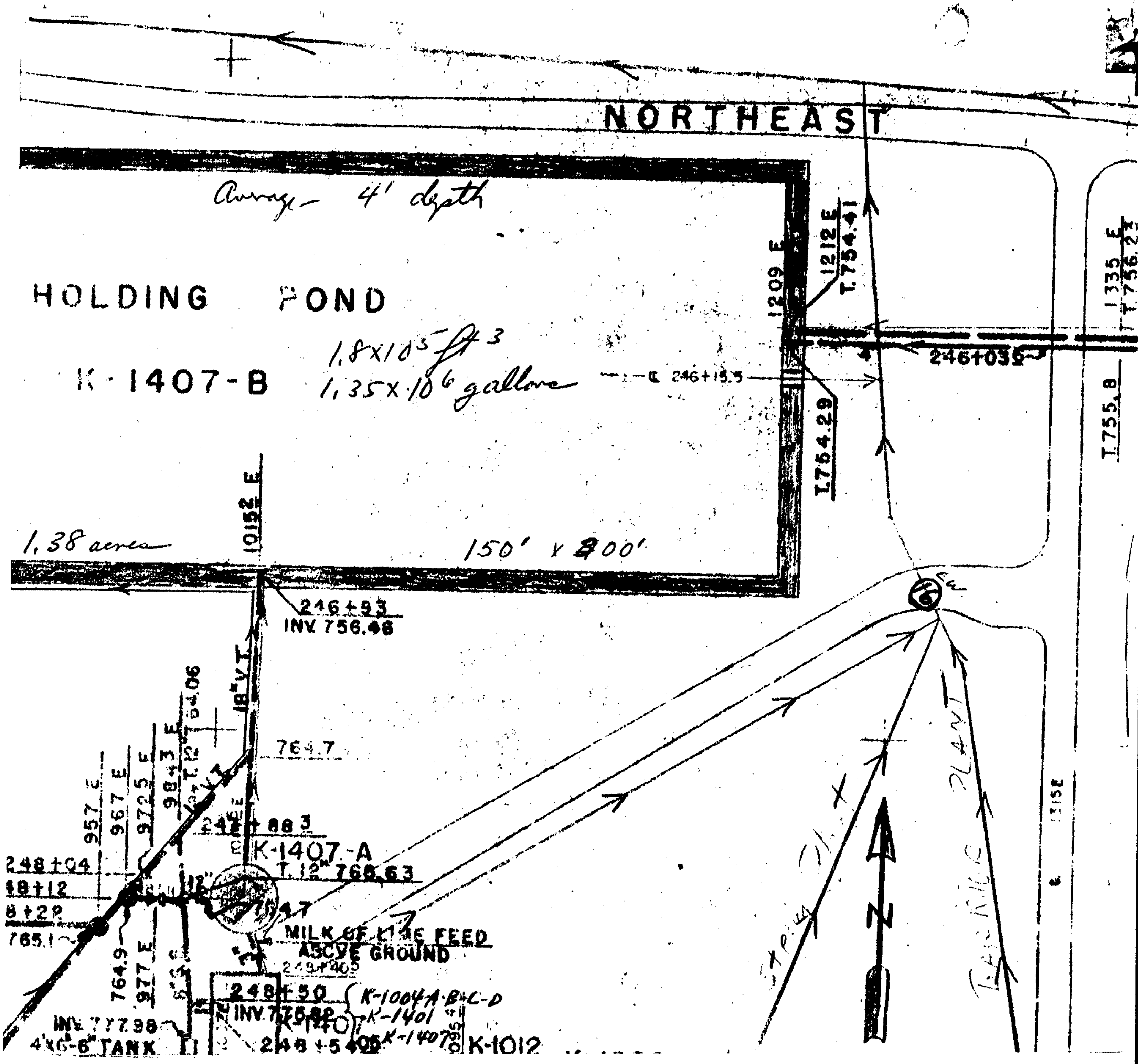
AIR

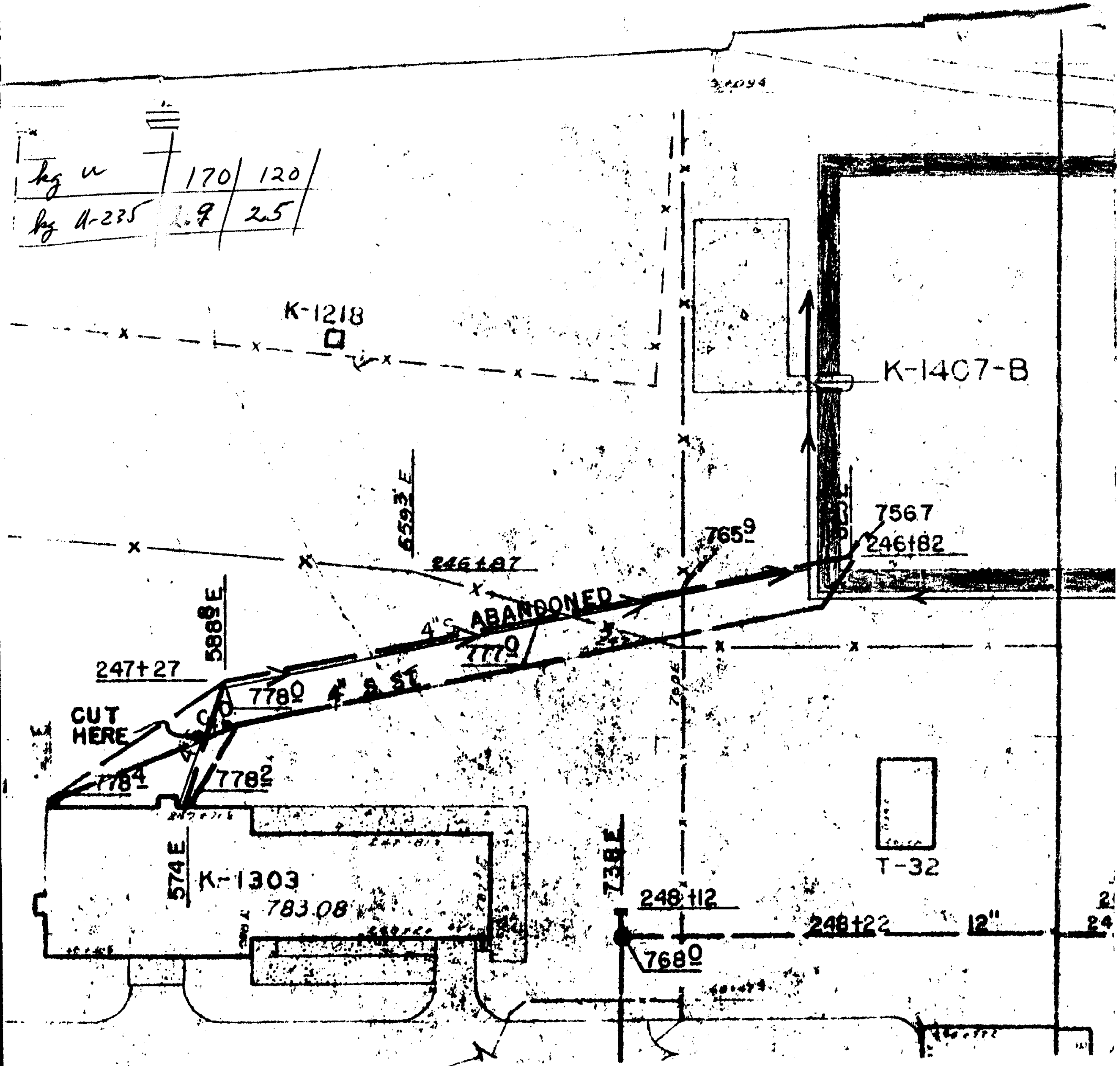
▼ Sampling Location - Five Miles from Plant

FIGURE 1



K-1420
8" TILE
4" TILE
245+55
245+98
246+98
246+33
246+23
246+35
246+65
246+69
246+75
246+72
246+56
246+744
247+36.5
248+41.6
1400 E
T. 757.93
1500 E
T. 764.59
1550 E
T. 765.61
1600 E
T. 766.19
1700 E
1775 E
T. 766.47
1879 E
T. 769.07
T. 768.87
T. 768.12
T. 770.10
T. 770.27
T. 767.21
T. 761.92
762.38
763.33
1568.5E
1548.5E
1870 E


NORTHEAST
HOLDING POND
K-1407-B
Average - 4' depth
1.8x10^5 ft^3
1.35x10^6 gallons
246+15.5
150' x 300'
1.38 acres
1209 E
1212 E
T.754.41
T.754.29
246+035
1335 E
T.755.8
10152 E
246+93
INV 756.46
18" V.T.
764.7
984.3 E
972.5 E
967 E
957 E
T.764.06
248+04
248+12
248+29
765.1
764.9
977 E
K-1407-A
T. 12" 766.63
MILK OF LIME FEED
ABOVE GROUND
248+50
INV 775.88
248+54
INV 777.98
4'x6'-6" TANK
K-1004A-B-C-D
K-1401
K-1407
K-1012
STORM
PLANT
CW
16
1315 E


kg U
170
120
kg U-235
2.5
K-1218
K-1407-B
6593 E
246+87
7659
7567
246+82
ABANDONED
4" C.I.
7770
247+27
5889 E
7780
4" S.ST.
CUT HERE
7784
7782
574 E
K-1303
783.08
738 E
248+12
248+22
12"
7680
T-32

specific activity: 2.5×10^4 d/sec/gram

Normal "U" in Potable Water

Permissible (NBS)	7×10^{-5} microcurie/ml	120 ppm
Local environs (1/10th)	7×10^{-6} microcurie/ml	

1957 Ft. Loudon background

Maximum 5×10^{-14} uc/ml **Minimum** 5×10^{-15} uc/ml

Enriched "U" in Potable Water

Permissible (NBS) U-233	1.5×10^{-4} uc/ml	1.2 ppm

Acceptable Emergency Beta (or Gamma) Activities in Drinking Water
("The Effects of Nuclear Weapons", US Dept of Defense, USAEC) (6-57)

Consumption period of 10 days	9×10^{-2} ~~μc~~/cc	3×10^3 d/sec/cc
" " 30 "	3×10^{-2} "	1×10^3 "

"If it appears that the period will be shorter, water of proportionately higher activity may be consumed in an emergency".

Handbook #52, "Maximum permissible amount of radioisotope in total body and maximum permissible concentration in air and water", Table 3.

Max. permissible amount for continuous exposure:
Sr^{90} & Y^{90}...........8×10^{-7} μc/ml of water

ORGOP = MPC x 1/10 x
= 2.4×10^{-7} μc/ml
= 0.53 d/min/cc

Handbook 69 NCRP (40th)/10 = FRL

Analysis	Precision at 95% Confidence Level
Uranium	± 20%
Alpha	± 20% Water ± 5% Mud
Fluorides	± 8%
Beta	± 14% Water ± 10% Mud

Stream	Approximate Flow		
East Fork	15 ft^3/sec	$3x10^7$ liters/day	8×10^6 g/day
Poplar Creek (ORGDP)	20 "	$5x10^7$ "	13×10^6 g/day
Clinch River (1959)	2850 "	$7x10^9$ "	1800×10^6 g/day

At estimated discharge rate of $2.5x10^3$ liters/day of contaminated waste (U) from ORGDP, and maximum permissible concentration of 12ppm in Poplar Creek, 240,000ppm U^n, or 2,400 ppm U of product assay. With changes in discharge rate, proportional changes in allowable concentrations for discharge would obviously need to be made. Criticality controls require consideration to be given to solutions with a U-235 concentration of 1,000ppm (x10 safety factor).

NBS:nbs
4/27/60

Normal U in Potable Water

Permissible (National Bureau of Standards)	7×10^{-5}	microcurie/ml
Local Environs Permissible (1/10th)	7×10^{-6}	"
Uranium contribution of recovered HF used to fluoridate water supply	7×10^{-13}	"
1957 Ft. Loudon Background (maximum)*	5×10^{-14}	"
1957 Ft. Loudon Background (minimum)*	5×10^{-15}	"

* H. H. Abbee, X-10 Health Physics indicated that daily samples are composited for quarterly samples, with 4 values reported each year.

NBS:nbs

M E M O R A N D U M

To: Files

Subject: Minimum Flows Recorded for the Clinch River in the ORGDP Area

From information received from the Scarbrough Gaging Station by the U. S. Geological Survey Department, the following minimum daily instantaneous readings and the minimum monthly averages have been recorded for the Clinch River Flow. The survey year runs from October 1 of the previous year to September 30 of the year stated.

Year		Flow (cu. ft. per second)	Period of Minimum Flow
1956 -	day	314	January 28, 1956
	month	2,691	February, 1956
1955 -	day	204	November 22, 1954
	month	1,685	November. 1954
1954 -	day	378	May 2, 1954
	month	1,769	February, 1954
1953 -	day	405	May 13, 1953
	month	1,524	May, 1953
1952 -	day	302	June 16, 1952
	month	2,162	May, 1952
1951 -	day	283	July 3, 1951
	month	2,109	April, 1951
1950 -	day	341	September 15, 1950
	month	2,599	July, 1950
1949 -	day	224	June 20, 1949
	month	1,033	July, 1949
1948 -	day	140	October 27, 1947
	month	1,939	October, 1947
1947 -	day	444	May 11, 1947
	month	1,035	May, 1947
1946 -	day	236	June 12, 1946
	month	568	April, 1946
1945 -	day	405	June 24, 1946
	month	1,918	May, 1945
1944 -	day	388	December 13, 1943
	month	1,192	January, 1944
1943 -	day	381	March 5, 1943
	month	2,647	March, 1943
1942 -	day	141	July 7, 1942
	month	273	May, 1942

G. S. Hill

G. S. Hill for
Safety and Health Physics

GSH:msp
NoRC
5/8/57

MEMORANDUM

To: Files

Maximum allowable limits of fluorides and hydrogen-ion concentrations of streams or rivers.

Water Pollution Abatement Manual
Manufacturing Chemists Assoc. Inc., 1948

Probably waters in which the pH neither falls much below 6.0 nor rises greatly above 8.0 are healthy for most fish, while a pH below 5.0 or above 9.0 is probably deleterious to most fish.

Aquatic Life Water Quality Criteria
Sewage and Industrial Wastes - Vol. 28
May, 1956 pp 686.

The U.S.P.H.S. has recently carried on bio assay studies directed toward the determination of the toxicity of fluorides to fishes. Tests were made with sodium, calcium, and potassium fluorides. On the basis of the amount added to the solution the 10-day TL_m (tolerance limit medium) of potassium fluoride was 64.5 ppm in soft water and 150 ppm in hard water. Since probably not more than 16-17 ppm of the fluoride were in solution at any one time and since some chronic effect was evident, it may be concluded that in the disposal of industrial waste, the fluoride content should be kept at less than 15 ppm. This amount is 10 times the concentration (1.5 ppm) considered safe for human use.

In view of these facts and the absence of data concerning chronic effects of fluorides on aquatic organisms and the knowledge that fluoride effects are cumulative in domestic animals, the Aquatic Life Advisory Committee recommends that fluoride-ion concentrations in any stream not be permitted at levels above those found safe for human consumption.

[illegible]:lh

[illegible] D. Hill for
Safety and Health Physics

July 19, 1956

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION OAK RIDGE, TENN.

TO Health Physics File

LOCATION

ATTENTION Mr. A. F. Becher

COPY TO

DATE September 16, 1952

ANSWERING LETTER DATE

SUBJECT Flow Volume for Poplar Creek

On August 16, 1952, Mr. L. C. McWilliams of the U. S. Geological Survey Department stated that 2 water flow measurements had been obtained on Poplar Creek and East Fork. These were taken at periods of minimum flow.

1. Poplar Creek on Highway 61, 2 miles from Oliver Springs toward Oak Ridge.

August 21, 1951 - 6.97 ft^3/sec.
October 15, 1951 - 6.19 ft^3/sec.

2. East Fork on Oak Ridge Turnpike approximately 5 miles from Oak Ridge.

August 21, 1951 - 18.0 ft^3/sec.
October 15, 1951 - 15.2 ft^3/sec.

Since East Fork enters Poplar Creek upstream from K-25, the total flow at K-25 as indicated by these measurements was at least as follows:

August 21, 1951 - 24.97
October 15, 1951 - 21.39. 21.39 ft^3/sec

J. C. Bailey
J. C. Bailey
Health Physics Section

JCB:mh

WCX-80 (6-51) THIS FORM FOR INTER-COMPANY CORRESPONDENCE ONLY

ROUTINE ANALYSES OF ORGDP SANITARY AND PROCESS WATER

SANITARY (Clinch River)

Bacteriological
Turbidity
Color
Residual Chlorine
Alkalinity
Total Hardness

PROCESS (Poplar Creek)

pH
Alkalinity
Total Hardness (Calcium plus Magnesium)
Calcium Hardness
Meta-OrthoPhosphate
Iron
Copper
Sulfate
Turbidity
Suspended Solids
Dissolved Solids
Chromates
Chlorides
Zinc

All Analyses performed weekly, by Utilities Laboratory

NBS:nbs
4/18/60

MEMO TO FILE

SUBJECT: Plant Effluents Resulting From Utilities Operations

The following are the approximate daily additions to the K-1407-B Holding Pond and/or Poplar Creek as a result of Utilities Operations:

1. Approximately three million gallons of recirculating water to which has been added 1100 pounds of No. 153-H "Crocol," composed of 60% sodium dichromate, 35% calgon, and 5% zinc sulfate.

2. Approximately 1000 pounds of "ferrofloc" (ferric sulfate coagulant) to the make-up water, most of which is blown-down from the treatment basins into the Holding Pond.

3. Approximately 7500 pounds of quick-lime added to make-up water, with disposal through the Holding Pond.

4. Approximately 500 gallons of sulfuric acid used for pH control. Since the acid converts the calcium carbonate to calcium sulfate, the sulfate radical rather than free acid is added to Poplar Creek.

5. Approximately 72 pounds of calgon per day in the sanitary water. This finds its way for the most part to Poplar Creek through normal channels such as sanitary sewers.

N. B. Schultz

N. B. Schultz

NBS:mh

3/20/62

1100 Bennett

Health Physics

PROCESS UTILITIES LABORATORY

CHEMICAL ANALYSES REPORT

DATE 3-3-62

TEST \ SAMPLE		~~MAKE-UP WATER~~			RECIRCULATING WATER				
		CW-1	CW-3	891-A	A-LOOP	B-LOOP	C-LOOP	E-LOOP	G-LOOP
pH		7.7	7.8						
Manganese	ppm								
"M" Alk. (as $CaCO_3$)	ppm	72	54						
Total Hardness "	"	98	82						
Calcium "	"	72	54						
Magnesium "	"	26	28						
M-phosphate (as PO_4)	"	.5	Trace						
O-phosphate (as PO_4)	"	.5	Trace						
Iron (as Fe)	"	.038	.03						
Copper (as Cu)	"	.04	.02						
Sulphate (as SO_4)	"	5	16						
Turbidity (as SiO_2)	"	15	27						
Suspended Solids	"	19	32						
Dissolved Solids	"	120	70						
Total Solids	"	139	102						
Chromates as CrO_4	"	.193	.039						
Zinc as Zn	"	.4	.4						
Chlorides as Cl	"	9	4						

Note: We do not have one of the necessary reagents for running nitrates but ordered some.

Signed W. W. George

WCX-748 (5-59) UTILITIES RL

TECHNICAL DIVISION

Special Analytical Services Department

ANALYSIS REPORT

Sample: No. 1 boiler and Nos. 5 and 8 condenser cleaning solutions

Sequence No.

Date Received: On or after 9/12/60

Request No. 29264

RESULTS

The following are the results of analyses made on Number 1 boiler chemical cleaning solutions.

Sample No. 1 (acid fill)
% Hydrochloric acid — 0.86

Sample No. 2 (acid drain) (31,000 gal.)
% Hydrochloric acid — [illegible]
Total solids — 31.04 lb.
Total copper in solids — 0.14 lb.
Total iron in solids — 5.37 lb.
Total copper in solution — [illegible] lb.
Total iron in solution — [illegible] lb.

Sample No. 3 (copper fill) [illegible],000 gal.)
% Ammonium hydroxide — [illegible]

Sample No. 4 (copper drain)
% Ammonium hydroxide — [illegible]
Total solids — [illegible] lb.
Total copper in solids — [illegible] lb.
Total iron in solids — [illegible] lb.
Total copper in solution — [illegible] lb.
Total iron in solution — [illegible] lb.

SUMMARY

1. Total Solids Removed

Acid drain — [illegible] lb.
Copper drain — [illegible] lb.
Total Solids Removed — [illegible] lb.

2. Total Copper Removed

[illegible]

Acid drain (solution) — [illegible] lb.
Acid drain (solids) — [illegible] lb.
Copper drain (solids) — [illegible] lb.
Copper drain (solution) — [illegible] lb.
Total copper removed — [illegible] lb.

CONTINUED ON PAGE 2

Submitted By: J. G. Elrod Location: K-793

Results Approved By: [signature] Date: October 3, 1960

TL-39 (6-57) NRC

ANALYSIS REPORT

Sample ____________________ Sequence No. ____________

Date Received ____________________ Request No. 2926

RESULTS

3. Total Iron Removed

Acid drain (solids)	5.37 lb.
Acid drain (solution)	94[illegible] lb.
Copper drain (solids)	1.65 lb.
Copper drain (solution)	3.6[illegible] lb.
Total iron removed	953.[illegible] lb.

The following are the results of analyses on Numbers 5 and 6 condenser cleaning solution. Results are on a per gallon basis.

Sample No. 5. Number 5 and 6 condenser fill (acid). (≈ 8,100 gal)

% hydrochloric acid	[illegible].21
Total solids	0.0001 lb./gal.
Total copper in solids	0.0000 lb./gal.
Total iron in solids	0.0001 lb./gal.
Total copper in solution	0.0[illegible] lb./gal.
Total iron in solution	0.0311 lb./gal.

Sample No. 6. Number 5 condenser acid drain.

% hydrochloric acid	1.92
Total solids	0.0[illegible] lb./gal.
Total copper in solids	0.0150 lb./gal.
Total copper in solution	0.01[illegible] lb./gal.
Total iron in solids	0.00[illegible] lb./gal.
Total iron in solution	0.[illegible] lb./gal.

Sample No. 7. Number 5 condenser drain (acid)

% hydrochloric acid	2.97
Total solids	0.0[illegible] lb./gal.
Total copper in solids	0.0[illegible] lb./gal.
Total copper in solution	0.0110 lb./gal.
Total iron in solids	0.0013 lb./gal.
Total iron in solution	0.[illegible]0 lb./gal.

Remarks ____________________

Submitted By ____________ Location ____________

Results Approved By ____________ Date ____________

... Boiler & Condenser Cleaning Solutions
(Sept 1960)

The analysis report is a sample of data filed in K-703 Power Operations office, Production Division. This data attached ... of the most recent boiler and condenser cleaning operations.

It should be noted that the concentrations reported represent concentrations in the cleaning solution which is diluted after release from the equipment, prior to discharge into Poplar Creek. The two sluice water pumps, rated at 1400 gpm each, 145 psi, will provide a total of about 2700 gal/minute at 150 psi at a point 100' from the pumps (pipe friction included), as dilution of the 31,000 boiler 8,000 cond. gal. of acid cleaning solution. Approximate dilution factor of

(a) x11 for boiler (2 hr. dump time) (31,000 gal) (2 sluice pumps)

(b) x30 for condenser (1½ hr dump time) (8,000 gal) (2 sluice pumps)

J. C. Elrod (PL8182)

J. D. McClendon (PL8270)

...

2/21/62

1. Extensive field and laboratory studies of the fresh-water streams of the United States show that general water conditions favorable to, not merely sublethal for, mixed fauna of game and food fishes and supporting organisms, present a complex defined by:

   a. Dissolved oxygen not less than 5 parts per million (lethal levels of dissolved oxygen vary from 0.56 parts per million for goldfish to 3.4 parts per million at 25°C. for trout. Since respiratory and circulatory compensations, which are distinctly undesirable in fish, begin long before these low levels are reached, the limit given seems to be the lowest value which may be reasonably expected to maintain a varied fish fauna. Cold-water fishes require even a higher dissolved oxygen level).

   b. Acidity range between pH 6.5 and 8.5. (Fish exhibit great tolerance for wide variations in the hydrogen-ion concentration. Ranges in pH beyond those given, however, are indicative of changes in the complex of dissolved substances normally found in inland streams that would prove harmful to fish.)

   c. Low density of ionizable salts as indicated by a conductivity between 150 and 500 mho X 10^{-6} at 25°C. and in general not exceeding 2,000 mho X 10^{-6} at 25°C. (Specific conductance, as here expressed, offers a ready method for detection of salt and acid pollutions as produced by water from coal mines and oil wells, by wastes from industries using salts and strong acids, and by heavy metals. It is not a measure of quantity alone but of the quantity together with the physical and electrical states of the salts.)

   d. Ammonia not exceeding 1.5 parts per million (Ammonia determinations give a significant index of the balance between stream purification and the amount of organic wastes received. Under average stream conditions where acidity ranges between pH 7.4 and pH 8.5, 2.5 parts per million of ammonia will be harmful to common aquatic species.)

   e. Suspensoids of a hardness of 1 or greater, so finely divided that they will pass through a 1,000 mesh (to the inch) screen; and so diluted that the resultant turbidity would not reduce the millionth intensity depth for light penetration to less than 5 meters. (Talc is designated as having a hardness of 1 in the series used by mineralogists. Millionth intensity depth for light penetration represents the depth at which the light is reduced to one-millionth of the surface illumination. The newer instruments for the measurement of turbidity; namely, the photolometer, the turbidity meter, and the photoelectric colorimeters give turbidity readings in percent of light screened out by samples of standard thickness. The millionth intensity depth for clear, unpolluted streams carrying little or no erosion material is 50 meters or more. The importance of light penetration in maintaining a favorable aquatic environment through the support of plant life need not be emphasized.)

2. Experimental data support these field and laboratory findings.

3. If such favorable conditions for fishes are to be maintained and fishes and other aquatic organisms are to be protected against the toxic actions of many stream pollutants, all pollutants not readily oxidizable or removable by the stream should be excluded, including particularly all cellulose pulps, wastes carrying heavy metallic ions and gas factory effluents. Other types of wastes should be diluted to concentrations nontoxic to the aquatic life of the particular stream. From that standpoint no substance should be added to stream waters which would cause a deviation in general conditions beyond the limits outlined above.

Copied from "Water Pollution in the United States", February 26, 1952;msp

MEMORANDUM

To: Files

Maximum allowable limits of fluorides and hydrogen-ion concentrations of streams or rivers.

Water Pollution Abatement Manual
Manufacturing Chemists Assoc. Inc., 1948

Probably waters in which the pH neither falls much below 6.0 nor rises greatly above 8.0 are healthy for most fish, while a pH below 5.0 or above 9.0 is probably deleterious to most fish.

Aquatic Life Water Quality Criteria
Sewage and Industrial Wastes - Vol. 28
May, 1956 pp 685.

The U.S.P.H.S. has recently carried on bio-assay studies directed toward the determination of the toxicity of fluorides to fishes. Tests were made with sodium, calcium, and potassium fluorides. On the basis of the amount added to the solution the 10-day TL_m (tolerance limit medium) of potassium fluoride was 64.5 ppm in soft water and 150 ppm in hard water. Since probably not more than 16-17 ppm of the fluoride were in solution at any one time and since some chronic effect was evident, it may be concluded that in the disposal of industrial waste, the fluoride content should be kept at less than 15 ppm. This amount is 10 times the concentration (1.5 ppm) considered safe for human use.

In view of these facts and the absence of data concerning chronic effects of fluorides on aquatic organisms and the knowledge that fluoride effects are cumulative in domestic animals, the Aquatic Life Advisory Committee recommends that fluoride-ion concentrations in any stream not be permitted at levels above those found safe for human consumption.

G. S. Hill for
Safety and Health Physics

GSH:lwh

July 19, 1956

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO Mr. A. F. Becher
LOCATION

DATE November 1, 1955

ATTENTION

ANSWERING LETTER DATE

COPY TO File

SUBJECT Mercury Contamination - Poplar Creek and Clinch River

Following up on the mercury contamination found in the Poplar Creek and Clinch River systems in the K-25 Area, the water samples taken during September showed the following results:

SAMPLING DATE	LOCATION			
September, 1955	CW-1 East Fork Junction of Poplar Creek	CW-5 Clinch River Influent of K-25 Sanitary Water	CW-6 K-25 Sanitary Water	K-891 Poplar Creek Process Cooling Water Influent
2	240 ppb	22 ppb	0 ppb	-
6	900 ppb	10 ppb	11 ppb	-
9	-	-	-	-
13	640 ppb	4 ppb	7 ppb	-
16	216 ppb	0 ppb	0 ppb	-
19	-	-	-	0 ppb
20	116 ppb	0 ppb	0 ppb	-
21	-	-	-	16 ppb
23	108 ppb	0 ppb	0 ppb	22 ppb
27	172 ppb	2 ppb	4 ppb	-
30	6 ppb	2 ppb	0 ppb	32 ppb

Samples taken at the Y-12 Weir and other Y-12 water effluents showed the following levels of mercury concentration:

September	ppb Mercury
9	816
12	876
Weekly Composite	992
13	1,536
13	2,500
14	2,200
15	1,900
Weekly Composite	1,900
19	1,500
Weekly Composite	2,000

September	ppb Mercury
Weekly Composite	1,660
20	2,110
21	1,560
23 and 24	1,020
Composite	1,040

Comments

A check with X-10 Health Physics reveals that, at the present time, there is no operation involving the use of significant amounts of mercury and the low levels noted at the sanitary water influent of the Clinch River indicates no significant upstream mercury pollution of the river by this installation. Comparatively large amounts of mercury are apparently released from the Y-12 operations into East Fork Branch with relatively high concentrations noted downstream as far as the Poplar Creek Intersection. In the Poplar Creek, however, the material is diluted considerably as shown by the samples taken at the K-891 Pump House.

G. S. Hill

G. S. Hill for
Safety and Health Physics

GSH:msp

NoK254C

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO Mr. A. F. Becher
LOCATION

DATE September [illegible], 1955
ANSWERING LETTER DATE

ATTENTION
COPY TO

SUBJECT A Review of the Mercury Levels Found in the K-25 Area of Poplar Creek and the Clinch River

During July, 1955, it was noted that the level of mercury in the K-25 Drainage Area of Poplar Creek and the Clinch River had risen sharply above the normal levels expected. Upstream sampling revealed that the material was being released by the Y-12 Installation into the East Fork Branch and thence to Poplar Creek and also was being pumped into a stream leading directly to the Clinch River at a spot upstream from the K-25 Sanitary Water Plant.

Findings

Sampling results showed the following levels:

Date of Sample	Hg (ppb) at the K-25 Clinch River Pump House	Hg (ppb) at the East Fork Mouth at Poplar Creek
July 26	22	560
July 29	32	1,800
August 2	28	200
August 5	2	64
August 9	8	20
August 12	0	16

Other checks made included:

K-25 Drinking Water

Location	Hg Concentration (ppb)
K-1002	0.00
K-1401	0.00
K-832	0.00

A Spot Check of Urine Samples*

No. of Samples	Hg Concentration (mg/l)
2	0.00
2	0.01
4	.02
3	.03
1	.04

Comments

Investigation and inquiries made by the Industrial Hygiene and the Safety and Health Physics Sections did not reveal any established M.A.C. for mercury for rivers or streams.

It is the opinion of the Industrial Hygiene Section that the results from the urine tests indicate no significant mercury ingestion and that at the present stream levels, no particular hazard to personnel is presented.

Spot sampling of the streams and the K-25 Sanitary Water Supply will be continued until the peak levels are established and the hazard adequately evaluated.

G. S. Hill
G. S. Hill for
Safety and Health Physics

GSH:msp

NoK25RC

*Includes personnel working in plant areas where mercury is handled routinely.

Dr H T Henry -
Stoddard advises no plant problem - literature indicates may be severe in its effect on marine life altho he could not furnish reference at this time
APR

MEMORANDUM

To: Files

June 24, 1955

Subject: A Review of the Excessive Alkalinity found in the Poplar Creek Drainage Area of K-25.

On June 3, 1955, the Utilities Department of K-25 notified the Safety and Health Physics Section that during their routine analysis of Poplar Creek water at K-802 it was noted that the P H values of the water indicated significant increases in alkalinity. A review of the findings is shown below.

DATE	HIGH p H VALUE
May 27	7.6
28	8.5
29	8.7
30	8.7
31	8.7
June 1	8.6
2	9.4
3	9.4
4	9.2
5	9.0
6	8.9
7	8.7
8	8.7
9	9.2
10	8.0
11	7.8

The peak of activity seemed to be reached on June 3, 1955, and during the entire day the P H remained well above a value of 9. Although occasionally the p H value will be 8.0 or slightly above for a short period of time, it is extraordinary for the value to remain above normal for such an extended period. As noted in the table, normal water conditions were not resumed until June 11, 1955. On June 3 an effort was made to determine the source of the release of material resulting in the stream changes and the East Fork sampling revealed the following:

LOCATION	p H
East Fork at Turnpike Roane County bridge	10.4
East Fork at Golf Course Road	9.5
East Fork at Jefferson Ave. & Turnpike	11.2
East Fork at Midway Gate near Y-12	11.0

In Poplar Creek the samples are a 3-day continuous sample collected on June 3.

Mouth of East Fork	10.0
Poplar Creek at Clinch River	8.0
Clinch River, 1 mile below plant	8.2

The highest activity was found at the points in the East Fork Branch nearest the Y-12 installation, indicating that this location is the source of the material released to the stream. A meeting was held with the Y-12 Industrial Hygiene representatives at which time they stated they knew of the source of accidental release which had resulted in the stream contamination. It was revealed that at the present time they do not routinely sample the East Fork Branch, and thus are not aware of any change in stream conditions until it is picked up at the K-25 sampling points.

Although during this period of high alkalinity in the stream no ill effect on the animal life, reflected by an abnormal death of fish, was noted, during the latter part of April hundreds of fish were killed in the K-25 Area of Poplar Creek and a check of the p H taken during this period showed that on April 22 the p H went up to 9.4 and remained high during the following day. Since the dead fish were not reported until early May it was not possible to locate the source from which the material was released. The Y-12 Industrial Hygienist indicates that a release of caustic solution occurred during this period of April at Y-12.

A second possible source may have been the acid released in the Clinch River following the cleaning of the Power House boilers which, due to the backflow of the Watts Bar Lake, was carried up Poplar Creek. This possibility seems highly unlikely since p H checks of the Clinch River indicated no significant rise in the p H level.

G. S. Hill

G. S. Hill

GSH:lwh

No K25RC

SA 4488
11/2/55

Sample Location	Date	ppb. Hg	ppm. Mn
Effluent Water Y-12 (9/9)	9/12	816	
" " " (9/12)	"	876	
" " " (Weekly Comp)	"	992	
" " " (9/13)	9/13	1536	
CW-1 (9/13)	"	640	
CW-5 "	"	4	
CW-6 "	"	7	
CW-1 (9/16)	9/20	216	
CW-5 "	"	0	
CW-6 "	"	0	
CW-1 (9/20)	"	116	
CW-5 "	"	0	
CW-6 "	"	0	
K-891 Supply (9/19)	"	0	
Effluent at Weir, Y-12 (9/13)	"	2500	
" " " (9/14)	"	2200	
" " " (9/15)	"	1900	
" " " Composite	"	1900	
" " " (9/19)	"	1500	
Y-12 Composite wk. ending 9/16	"	2000	
891 Composite (9/21)	9/21	16	0.1
CW-1 (9/23)	9/26	108	
CW-5 (9/23)	"	0	
CW-6 (9/23)	"	0	
K-891 Supply (9/23)	"	22	
Effluent at Weir Y-12 Composite	"	1680	
" " " (9/20)	"	2110	
" " " (9/21)	"	1860	
" ", (72 hr. 23 & 24)	"	1020	
CW-1 (9/27)	9/28	172	
CW-5 (9/27)	"	2	
CW-6 (9/27)	"	4	
CW-1 (9/30)	9/30	6	
CW-5 "	"	2	
CW-6 (9/30)	"	0	
K-891 Supply (9/30)	"	32	
~~Poplar Creek~~ composite wk. end. (9/30)	"	1040	

Y-12 [illegible]

10/4/55

INTER-COMPANY CORRESPONDENCE

(INSERT NAME) COMPANY CARBIDE AND CARBON CHEMICALS COMPANY LOCATION Post Office Box P OAK RIDGE, TENN.

TO Mr. W. L. Richardson
LOCATION K-1001
ATTENTION
COPY TO

DATE September 7, 1955
ANSWERING LETTER DATE
SUBJECT Mercury in Sanitary Water

Although the levels of mercury in our sanitary water have been as high as 30 ppb., there does not anywhere appear to be any information on potential hazards of mercury ingestion, although inhalation is known to be very dangerous. In this, mercury is probably somewhat like uranium where the ratio of amounts that can be safely eaten as compared to that safely inhaled is of the order of 1000.

The Medical Department is aware of the water contamination and has made some clinical checks of employees not exposed to mercury in their normal work; no indication of mercury excretion or other body effect has been found.

H. F. Henry
Safety, Fire, and Radiation Control

HFH:mh

NoK25RC

Dr. Henry: What are the amounts generally found in nature and so-called potable drinking water?
What is the source of mercury in our water?

WLR

WLR: Normally 0; we do not know of any locations where the water level is higher but I'm sure they exist. The danger level is unknown.

Y-12 has been accused of being the source. There is a much higher level in Poplar Creek. However according to Hungerford, X-10 "lost" a good bit of mercury a year ago; thus, they are probably the culprits.

HFH

9/9/55: Let's keep this under scrutiny and advise me when it gets worse or cleared up. Our file should reflect disposition of such matters.

WLR

OK - HFH

ORGDP ENVIRONMENTAL MONITORING

Water and Mud

In discussing the ORGDP water and mud sampling program, we will include both our legal and moral responsibilities in controlling exposure to the general population downstream from the UCNC plants in Oak Ridge. The ORGDP routine monitoring program, emergency controls, and comparison of the actual radiation levels in the ORGDP environs with maximum permissible concentrations recommended by the NCRP are also discussed.

In 1945 Tennessee passed a stream pollution act to regulate and control the pollution of the surface waters and streams of the state; this act is administered by a Control Board, whose membership includes representatives from industry, public health, municipalities, and conservation. The state law indicates that no substances should be discharged to the waters which may produce toxic conditions that materially affect man, animals, and aquatic life, or impair the potability of a treated water supply. With its limited personnel and equipment, the state commission relies upon the ORO of the USAEC and the TVA for information as to their waste disposal problems and stream levels affected by their operations.

Under the AEC Regulation, Chapter 0524, standards established by the NCRP and recommended by the NBS are to be considered as minimum requirements for commission contractors.

ORGDP SPP-310, entitled "Disposal of Hazardous Materials" outlines the plant policy relative to disposal of hazardous materials. This provides that such disposal be in accord with applicable laws and regulations to preclude endangering persons, property, animals, or vegetation. The limitation of exposure for those under 18, as well as for adults living in areas proximate to the plant shall be only one-tenth the amount permitted for the plant population, and that all other areas shall not receive significantly more than background levels of radiation.is an indication of the levels sought.

Our objectives are to protect our plant population as well as the general population downstream. Protecting ourselves involves evaluating and controlling the fission product contamination in the ORGDP sanitary water in order to assure that personnel exposures due to this source are less than 10% of the P.A.L. for total body exposures. Protecting the general population involves detection of contaminants not only in our plant effluents but also the combined effect of all of the UCNC plants at Oak Ridge and institution of controls where needed to prevent stream pollution deleterious to marine, plant, or animal life. We must also have plans for handling emergency conditions which may result from abnormally high concentrations of radioactive contaminants in the ORGDP sanitary water supply.

<u>(Map of Tennessee River)</u>

The flow of water in the reach of the river of interest to us is controlled by the discharge from Norris Dam and the elevation of the water impounded by the Watts Bar Dam.

<u>(Map of ORO Area)</u>

It may be seen that disposal from Y-12 is dispersed into the Clinch River by way of Bear Creek, East Fork of Poplar Creek, and Poplar Creek itself. ORNL waste disposal is via the low-level waste pits to White Oak Lake and thence to the Melton Branch of White Oak Creek and the Clinch River.

<u>(Map of ORGDP)</u>

The ORGDP sanitary water supply is taken from the Clinch River approximately one mile upstream from the Powerhouse and about six miles downstream from the ORNL plant site. Mixed fission product waste materials are routinely released from the ORNL to the Clinch River via White Oak Creek. Formerly the creek had been dammed and formed what was called the White Oak Lake which acted as a holding basin for the ORNL waste materials; however, due to the lack of adequate weiring and flood gates at the dam outfall, little if any control of the discharge could be made following heavy rainfall or during flooding. The lake was drained in 1956 and, at the present time, the waste materials enter the creek and pass in a relatively steady controlled flow into the river. As a result of this controlled release, the activity in the river has been maintained at a more constant level with a minimal number of high peaks of activity such as were noted during the period of uncontrolled flows from the White Oak Lake. Dilution of radioactive contaminants released from White Oak Lake depends on the Clinch River flow. Actual current flow and predicted future releases of water from Norris Dam are made available by the TVA with about a two-day lag. ORNL has a policy of releasing only that amount of activity which will give below-tolerance concentrations following dispersion and dilution in the Clinch River based on the predicted TVA flow rate and assuming homogeneous mixing in the river between ORNL and ORGDP. Thus, while concentrations of radioisotopes should normally be less than the permissible levels at the ORGDP water treatment plant intake, they may be exceeded on occasion. The isotopes of immediate concern in this connection are Sr^{89} and Sr^{90}. Sr^{90} is particularly hazardous to man because it is chemically similar to calcium, and the human system readily absorbs it along with the calcium in vegetables and deposits it along the surfaces of the bones in the human skeleton where it can irradiate the blood-producing marrow inside the bone.

It is well to remind ourselves that the MPL's for these materials are based on the possible genetic effect on huge populations if encountered over a lifetime; no clinically detectable injury is experienced at these levels;

they are used as control points to integrate exposure over longer periods, at least 13 weeks, and the average level found in our water supply is only a fraction of the MPL. The difficulties in exactly calculating the number of curies to release to assure safe limits for all users may be noted by the wide variations in the Clinch River rate of flow during a 24-hour period, its stratified stream flow, the effects of numerous sharp bends in the river course, and differences in depths of stream bed.

(Photograph of K-1513 Sampler)

The raw water supply is sampled at the K-1513 Pump House where the water is taken from the Clinch River. This sampler is an electrically operated water-wheel type of drive to which a sample bucket is attached. You may note the resemblance to the children's sand-box toy, "Sandy Andy." About 10 ml. of water is discharged every two minutes to a five-gallon carboy which is composited to reflect a seven-day proportionate sample.

Since the plant allowable limit for beta activity in the plant drinking water is based on that which is due to Sr^{90}, the most hazardous of the mixed fission product waste materials, and the concentration of this isotope has varied from 25% to 100% of the identifiable fission product wastes, it is necessary to determine that portion of the total beta activity measured which is due to the Sr^{90} isotope. The levels of activity due to this isotope which are of concern are so low as to not be measurable with usual survey instruments, nor even normal laboratory procedures. Since this is so, an ion exchange method has been developed to concentrate the Sr radioactivity in the plant water supply. This is installed at the K-1515 Water Treatment Plant, and a 24-hour sample is collected each morning at 7:00 a.m.; the analysis and counting of the sample is completed by 4:00 p.m. of the same day.

A second continuous collecting device is located in the finished sanitary water system at the K-1515 Post Chlorinator position. This device utilizes a needle-valve which permits adjustment to secure a proportionate sample; the water drips continuously into a carboy and, here too, the sample is composited weekly. Other check points for determining the total beta activity in the treated sanitary water supply include spot sampling of the plant drinking fountains and the cafeteria cooking water supply.

All of the plant waste materials are released into Poplar Creek which bisects the ORGDP area and then empties into the Clinch River about one-half mile downstream from the last major drain effluent. Poplar Creek also carries the Y-12 Plant waste materials released into the East Fork Branch which subsequently empties into Poplar Creek about one-half mile above ORGDP.

Radioactive materials in streams are absorbed by biological organisms, by clay particles occurring as turbidity in streams, or precipitated out by either physical or chemical means, resulting in the accumulation of radioactive substances in the sediment. Naturally occurring radioactive isotopes of uranium, thorium, and potassium, account for from 25% to 40% of the radioisotopes in the Clinch and Tennessee Rivers; the remainder of the radioactivity is from fission products of which the most prominent are ruthenium, cesium, cobalt, and cerium.

(Photographs of Mid-stream Sampler)

Continuous water sampling devices are placed in three mid-stream locations in order to detect the uranium concentration of Poplar Creek and the downstream dispersal and dilution of the radioactive contaminants in the Clinch River. These sampling units consist of a small raft from which a weighted carboy is suspended, being adjustable to varying depths. A capillary adjustment, allowing a constant displacement of air by water into the carboy, is regulated to provide a proportionate weekly sample which is then composted for analysis. These continuous samples are located as follows:

a. East Fork Branch near its junction with Poplar Creek, which permits the amount of waste material reaching Poplar Creek from the Y-12 Plant to be calculated.

b. Poplar Creek near its junction with the Clinch River; this measures the total uranium concentrations in the stream and, since the East Fork concentration is known, the net ORGDP contribution may be calculated.

c. Clinch River one mile downstream from the Poplar Creek junction measures the contribution of all of the waste materials contributed by the three Oak Ridge Plants.

In addition to the composite water samples, spot samples of stream bottom mud and certain building drain systems are taken quarterly to evaluate any possible build-up of contaminated silt, as well as to check on operational changes which may produce abnormal releases of materials. All water samples taken are analyzed for total uranium content and the associated alpha and beta activity; in addition, the fluoride content and pH values are also measured. Other routine checks include those made of the acid drain lines, wastes from the laboratory areas, and the sewage disposal plant sludge which is sampled before it is dumped.

Special studies are made periodically of the accumulation of radioactivity by the absorption of uranium from the slightly contaminated plant effluents in clay, silt, vegetation, and fish.

Emergency Controls

In the event of an accidental spill or release of waste material at ORNL which would result in an abnormally high level of beta activity in the White Oak Creek, certain emergency procedures have been suggested to minimize the

the possibility of contaminating the ORGDP sanitary water supply.

In the event of a "known" release from ORNL, which may be controlled behind White Oak Dam, the material would be held up until it can be released slowly into the Clinch River and thus adequately diluted. The potential danger due to overfilling of the lake with a subsequent uncontrolled release or unusually heavy rainfall would exist; however, this is considered remote.

If the high activity reaches the Clinch River, ORNL authorities will alert the ORGDP Shift Superintendents, who, in turn, will notify the Utilities Department and other staff groups as indicated. Sampling frequency would be increased at the raw water intake, and sanitary water consumption reduced to extend the normal nine-hour reserve supply. Disaster control actions, if indicated, would include shut off of raw water intake, further limitations of sanitary water consumption, provision of potable water from an uncontaminated source, and continued sampling of raw water until levels return below the action point.

In the event of an "unknown" release from upstream which is first detected at the ORGDP K-1515 Sanitary Water plant, when noted for the second consecutive day ORNL will be requested to check their discharge of waste and initiate control measures. If ORNL does not find a continuing release and identifies the "slug" which was sampled, then the high activity may be expected for no longer than approximately 48 hours. If ORNL discovers a continuing release of high activity radioactive contamination, and controls can be quickly established, then the situation can be covered as above. If controls cannot be immediately established, the period over which the release will continue uncontrolled is evaluated and the new exposure rate is calculated; if it is less than the control point, no further actions need be considered. If the calculated dose rate is greater than the control level, then disaster controls will be initiated.

(Chart, MPL and Current Values)

MPL's are established by NCRP and recommended by the NBS. Since all of these limits are given for continuous exposure, the corresponding plant limits for a 40-hour week can be three times the continuous exposure value. However, for administrative purposes to avoid the need for integrating employee dose from all exposure sources, our plant limits specified for the potable water supply are set at < 10% of these permissible levels. The problems of health hazards involved in the discharge of uranium materials in the ORGDP waste appear of minor consequence in view of the stringent limits desired for economical reasons.

These average values indicate that the activity levels in the water and bottom sediments in the Clinch and Tennessee Rivers resulting from waste release by the three Oak Ridge plants are well below those recommended by the NCRP and thus do not represent any hazard to the plant or the population in the areas adjacent to the plant. However, continuing vigilance must be maintained to insure that build-up or reconcentration of the radioactive materials do not create a problem at some future date.

NBS:la

8/14/59

MEMORANDUM

To: Files

Maximum allowable limits of fluorides and hydrogen-ion concentrations of streams or rivers.

Water Pollution Abatement Manual
Manufacturing Chemists Assoc. Inc., 1948

Probably waters in which the pH neither falls much below 6.0 nor rises greatly above 8.0 are healthy for most fish, while a pH below 5.0 or above 9.0 is probably deleterious to most fish.

Aquatic Life Water Quality Criteria
Sewage and Industrial Wastes - Vol. 28
May, 1956 pp 685.

The U.S.P.H.S. has recently carried on bio assay studies directed toward the determination of the toxicity of fluorides to fishes. Tests were made with sodium, calcium, and potassium fluorides. On the basis of the amount added to the solution the 10-day TL_m (tolerance limit medium) of potassium fluoride was 64.5 ppm in soft water and 150 ppm in hard water. Since probably not more than 16-17 ppm of the fluoride were in solution at any one time and since some chronic effect was evident, it may be concluded that in the disposal of indistrial waste, the fluoride content should be kept at less than 15 ppm. This amount is 10 times the concentration (1.5 ppm) considered safe for human use.

In view of these facts and the absence of data concerning chronic effects of fluorides on aquatic organisms and the knowledge that fluoride effects are cumulative in domestic animals, the Aquatic Life Advisory Committee recommends that fluoride-ion concentrations in any stream not be permitted at levels above those found safe for human consumption.

G. S. Hill for
Safety and Health Physics

GSH:lwh

July 19, 1956

- 0.86 Tons / days to be dumped at below 2.5%

- May pass through slakelime to ppt the fluorides

Flow of Poplar Creek (estimated min flow)
21 ft^3/sec or 5 X 10^7 liters/day
Flow of Clinch River — 1955 Av - 4,200 ft^3/sec Min. - 1,510 ft
Normal pH of Poplar Creek is approximately 7.5

Calculated pH level - ?
Calculated fluoride level - ?

Allowable pH level — 5.0 - 9.0
" fluoride level - 15 ppm in Poplar Creek
1.5 ppm Clinch River

"Water Pollution in the U.S." Feb 26, 1952
Acidity ranges between pH 6.5 - 8.5 is favorable not merely suitable for fishes supporting organisms. Fish exhibit a great tolerance for wide variation in the hydrogen-ion concentration. Range beyond these, however, are indicative of changes in the complex of dissolved substances normally harmful to fish.

U alpha

1 ppb ≅ 7×10^{-10} μc U^N/ml water

1 ppb ≅ .001 μg U^N/g H_2O

U^N ≅ 2.5 $\times 10^4$ d/s/g
1.5 d/m/μg

1 d/m/ml ≅ 45 $\times 10^{-8}$ μc/ml

Sr^{90} Beta

.53 d/m/ml = 2.4×10^{-7} μc/ml
1.00 d/m/ml = 4.4×10^{-7} μc/ml

Environmental Contamination (Weinstein)
HASL — USAEC — NY.

Pg 180

No standard for U in soil + muds

10 CFR Part 20 says: {water} {above natural background} (unrestricted): 10.4 μg U / g of water

D.E. Lynch: natural soil uranium — 3-9 μg U/g

Suggested $MPC_{(SOIL)} = 100 \times MPC_W = 1040$ μg U/g water.

Soil conc. decreased linearly with distance — indistinguishable from local background beyond about 2000' from the center of plant activities —

1" — (2-3)X the next 5"

Handbook #52

"Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water."

$\mu c = (\text{dis/sec})(2.7 \times 10^{-5})$

$d/\text{sec} = (\mu c)(3.7 \times 10^{4})$

Poplar flow:

5×10^{9} liters @ 1.2×10^{7} gal /day.

@ 10×10^{7} # /day

MAC Water — (beyond plant control)

F_2 1.5 ppm

U 10.3 ppm

α 1554 d/m/100 ml

U_N $2.1 \times 10^{-5}\ \mu c/\text{cm}^3$ } of water

48 d/m/ cm^3 = 3.9×10^{4} ppb U_N

Spec activity = 1512 d/m/mg (α @ lita)

β $1 \times 10^{-7}\ \mu c/\text{ml}$ (22 d/m/ml) ?

pH 6.0 — 8.0

F 1.5 ppm

STANDARD PRACTICE PROCEDURE

OAK RIDGE GASEOUS DIFFUSION PLANT
Operated By
UNION CARBIDE NUCLEAR COMPANY

Subject: DISPOSAL OF HAZARDOUS MATERIALS

A. POLICY: It is plant policy to dispose of hazardous materials in accordance with applicable laws and regulations and to make certain that persons, property, animals, vegetation, and natural resources are not endangered by such disposal.

B. DEFINITIONS:

1. Hazardous material is any material in quantities which, as a consequence of its chemical, radiological, or biological properties, may injure or damage persons, property, animals, vegetation, or natural resources.

2. Disposal, as used in this procedure, does not include the removal of hazardous material from the plant area for storage, sale, use, or processing at another location.

C. RESPONSIBILITIES:

1. It is the responsibility of supervision of the department in which the material is located to:

   a. Make every effort to determine the identity and hazards associated with the material prior to disposal.

   b. Request advice, analytical services, and technical assistance from appropriate plant groups where the identity of the material or the hazards associated with the disposal of the material are unknown or when otherwise indicated.

   c. Prevent the unnecessary accumulation of hazardous material.

   d. Make certain that persons, property, animals, vegetation, or natural resources are not endangered by the disposal of hazardous material.

   e. Specify the method to be used and the procedure to be followed in the disposal of hazardous material.

   f. Dispose of or arrange for the disposal of surplus hazardous material in accordance with applicable laws and regulations.

2. It is the responsibility of the Industrial Relations Division to:

   a. Monitor the air, streams, and plant area to determine the existence of any danger to persons, property, animals, vegetation, or natural resources.

   b. Audit and evaluate methods of disposing of a hazardous material.

   c. Advise plant personnel concerning requirements for compliance with applicable laws and regulations as requested.

Approved By:

Subject: DISPOSAL OF HAZARDOUS MATERIALS

C. RESPONSIBILITIES:

2. (continued)

   d. Provide advice and technical assistance concerning the appropriate method of disposing of a hazardous material as requested.

D. REGULATIONS:

1. Disposal of hazardous material will be accomplished within the plant area. Outdoor areas which are used for such disposal will be identified with appropriate signs and markers.

2. Material which cannot be identified will be disposed of as hazardous material.

3. Hazardous material will be pretreated by appropriate means to eliminate the hazards when hazardous materials are released into plant sewer, trash disposal, and venting systems.

E. PROCEDURE:

Supervision of the department in which the material is located:

1. Determines in each case the procedure for the disposal of the material.

2. Informs personnel concerned of the procedure to be followed. As appropriate, this may include a detailed written procedure for a specific disposal action.

3. Disposes of or arranges for the disposal of the material.

Approved By: A P Hurlin

ORGDP SANITARY WATER PLANT INTAKE
BETA ACTIVITY (dis./min./100 ml)
COMPARISON OF COMPOSITE AND MONITOR RESULTS

Date	Weekly Average Composite	Weekly Average Monitor	Monitor: Composite	13-Week Average Composite	13-Week Average Monitor	Monitor: Composite
1959						
10/3	4					
10/10	21					
10/17	22					
10/24	36					
10/31	30					
11/7	245					
11/14	54					
11/21	66					
11/28	154					
12/5	555					
12/12	111					
12/19	1047					
12/26	301					
1960						
1/2	218	339	1.6	232		
1/9	451	773	1.7	254		
1/16	244	280	1.1	279		
1/23	272	193	0.7	294		
1/30	217	291	1.3	303		
2/6	468	816	1.7	320		
1960						
2/13	524	1745	3.3	356	494	1.4
2/20	584	1567	2.7	396	612	1.5
2/27	266	911	3.4	404	677	1.7
3/5	273	2313	8.5	383	844	2.2
	3517	9228	2.6	1539	2627	1.7

NBS:la

Safety and Health Physics
Industrial Relations Division

March 18, 1960